水路部報告

第五卷

大正十二年日本磁氣測量

THE

BULLETIN

OF THE

HYDROGRAPHIC DEPARTMENT, IMPERIAL JAPANESE NAVY.

VOLUME V.

Tokyo, 1926

水路部報告

第五卷

大正十二年日本磁氣測量

THE

BULLETIN

OF THE

HYDROGRAPHIC DEPARTMENT, IMPERIAL JAPANESE NAVY.

VOLUME V.

A Magnetic Survey of Japan for the Epoch 1923.0,
Executed by the Hydrographic Department.

大正十五年

水路部

Hydrographic Department

1926

PREFACE.

The second decennial magnetic survey of Japan, published in the present Volume V of the Bulletin of this Hydrographic Department, was executed in the interval between June, 1922, and August, 1923, and covers the entire extent of Japan, comprising the Marshall, Caroline, and Mariana archipelagos. The instruments used throughout this survey of Japan are Barrow's Dip Circles and the electric magnetometers invented by Engineer N. Watanabe of this Department, which in many respects greatly facilitated the work and added to its accuracy.

It is to be greatly regretted that all original records of the present survey were destroyed by the earthquake and fire of September, 1923, only rough sketches, which supplied the data for the present publication, having fortunately been saved from the calamity.

For the computation of the distributions of magnetic elements and their secular variations over the Far East, we acknowledge our indebtedness to the Marine Department of the Chinese Maritime Customs, which supplied us data for the Chinese coast. The Chinese Government readily accepted our invitation to co-operate with us and conducted their survey between May, 1922, and February, 1923. We have freely referred to the results of land and ocean magnetic observations by the Carnegie Institution of Washington in and around the Pacific Ocean and by the local magnetic observatories. Our best thanks are due to Prof. Dr. A. Tanakadate, who revised this volume, and to all the members of the staff, to whose devotion and zeal the work owes its completion.

S. YONEMURA, Rear-Admiral,
Hydrographer, Imperial Japanese Navy.

CONTENTS.

TABLES.

MAPS.

SUMMARY OF THE MAGNETIC SURVEY OF JAPAN FOR THE EPOCH 1923.0.

This survey is the second of the decennial magnetic surveys of Japan commenced in 1913 by the Hydrographic Department of the Japanese Navy. The results of the first survey were published in Vol. II of the Bulletin of the Department.

While we were planning the survey, the Chinese Government agreed to our suggestion that they undertake their survey of the Chinese coast at the same time. The survey of the Chinese coast was executed by the Marine Department of the Chinese Maritime Customs. The observer employed on this survey had been trained at the Lukiapang Observatory near Shanghai. The comparison of our instruments with those used by the Chinese observer was conducted at the Lukiapang Observatory. Our best thanks are due to Captain Eldridge, the director of the Marine Department, and Mr. von Ravens, a member of the Department, for the assistance they had given our observers when at Lukiapang and for their courtesy extended to them at the time of the comparison of the instruments. It is also our pleasant duty to express our thanks to Father Moidrey, the director of the Lukiapang Observatory, for his aids to the work of observation and comparison.

Marshall, Caroline, and Mariana Islands were placed under the Japanese mandatory rule subsequent to the first survey and the region of the present observation was therefore extended to these islands.

After the first survey, Engineer N. Watanabe investigated for surveying purposes the electro-magnetic method of measuring horizontal intensity, and his studies resulted in designing new magnetometer theodolites, which, compared with those used in the previous survey, show many points of improvement in construction suggested by the experiences of the previous survey. By reason of the shortage of skilled labour, caused by the great war, no magnetometer of the improved type could then be obtained from either foreign or Japanese makers. An order for a number of the new type instruments was eventually placed with the Naval Arsenal of Tôkyô.

We wish to express our sincere thanks to the officers of the Arsenal, especially to Naval Engineer Tosio Kawamura, who devoted so much of his time and attention to the completion of the mechanical design of the instrument, which served its purpose throughout the survey.

The survey commenced at the beginning of June, 1922, was finished at the end of August, 1923, when our computers set about their work. With the destruction of our Department edifices by the great earthquake and fire of September 1st, all records concerning the standardization of the instruments together with all records of the observations of the second decennial survey were lost. Only the sketches of observations sent from each station narrowly escaped destruction, and the computations were made from these sketches. Much of the details could not be given on account of the loss of the records, note books, etc. .

For the purpose of the present computations, the data furnished by the magnetic observatories in and around the Pacific Ocean and given in the publications of the Carnegie Institution of Washington were utilized in addition to the data of the Chinese and our own surveys. Thus the region of the isomagnetic curves is extended from 55°N to the equator in latitude, and from 115° E to 175° E in longitude, while the region in the previous survey was from 50°N to 20°N in latitude, and from 120° E to 145° E, in longitude.

PART I.

ORGANIZATION OF THE SURVEY, DESCRIPTION OF THE INSTRUMENTS, THEIR STANDARDIZATION, COMPARISON AND METHOD OF OBSERVATION.

Organization of the survey.

The personnel of the survey consisted of the following staff and observers:

The staff:—

Division of Instruments	*Noboru Watanabe*, Naval engineer and Member of Central Bureau of Weights and Measures of Japan.
	Tosio Kawamura, Naval Engineer.
Division of Computation.	*Asaiti Muramoto*, Naval Engineer.
	5 to 6 Assistants.

Observers, divided into three parties:—

1st. party.	*Tosihiko Ogawa*, Hydrographic Commander.
	Bunpei Kobayasi, Assistant.
2nd. party.	*Yukiyosi Ôtani*, Hydrographic Commander.
	Kingo Nagoya, Assistant.
3rd. party.	*Kôzi Kobayasi*, Naval Engineer.
	Gorô Oka, Assistant.

The Stations.

After the date of our previous survey, the magnetic data for China and the Western Pacific Ocean were published chiefly by the "Carnegie Institution of Washington", and the region under survey was extended to Marshall, Caroline, and Mariana Islands for our observers, and to the Chinese coast for Chinese observers. We did not therefore require so many stations in Japan itself as on the occasion of the previous survey.

About 150 stations were selected, care being taken to ensure that they are distributed as evenly as possible over the whole area to be surveyed, keeping it in view at the same time to repeat as many stations of the previous survey as possible. Those stations, however, which were supposed to show magnetic anomalies according to the computation of the previous survey, were excluded in order to arrive at the general features of magnetic elements over the whole area.

In an island, two or more stations symmetrical in their topographical aspects were chosen with the object of compensating, in their mean, the effect of its magnetic perturbation.

The number of the stations is tabulated below:—

Regions	Kinds of Stations					Total number of stations. 1923	Total number of stations 1913.
	New stations	Repeated Stations					
		A	B	C	D		
Karafuto	2	4				6	19
Hokkaidô		7		5		12	39
Honsyû		33	1	7	1	42	112
Sikoku		5				5	16
Kyûsyû	2	12	1			15	34
Tyôsen	7	15	2	3	1	28	78
Kwang-tung Peninsula	2					2	
Tsingtau	1					1	
Ryûkyû	1	2			1	4	10
Taiwan	1	5		1	1	8	16
Ogasawara		3			4	7	7
Mariana Is.	3					3	
Caroline Is.	12					12	
Marshall Is.	3					3	
Sum	34	86	4	16	8	148	331

The categories A, B, C, D of the repeated stations mentioned in the

column for the kinds of stations denote :—

A , that the position of the station and its surroundings are the same as those of 1913 survey.

B , that the position of the station is the same as that of 1913 survey, but its surroundings were changed.

C , that the position was slightly changed, but the surroundings remained the same.

D , that the new position was found near the station of 1913 survey.

The stations on the Chinese coast were chosen with due regard for the convenience of transportation as well as the desire to repeat observations made by the "Carnegie Institution of Washington." The total number of such stations was 13. But observations were made at two or more spots in some stations, bringing the total number of the points observed to 18.

Equipments.

Each party was equipped with a set of magnetometer-theodolite, a siderial chronometer, a mean-time deck watch, two tents, a folding sofa, dry cells, small electric lamps, and a box of necessary tools and materials, besides being provided with copies of "Berliner Jahrbuch" and "Nautical Almanac", a logarithm table, and field books.

The magnetometer was an electric one but a deflection bar, a bar magnet etc. for the method of Gauss-Lamont were also included in the equipment, because we had no previous experience of the transportation of an electric magnetometer from place to place, and could not, at commencement of the survey, rely upon an electric magnetometer alone.

The tents were the same as those used in the previous survey. Their general conditions are given in the report on the previous survey, "Bulletin of the Hydrographic Office, Imperial Japanese Navy. Vol. II, 1918."

The following list shows the instrumental equipment of each party :—

	Magnetometer-theodolite.	Electric coil.
1st. party	No. 1.	No. 1.
2nd. party	No. 3.	No. 3. & No. 4.
3rd. party	No. 2.	No. 2.

One terminal of wire of the electric coil No. 3 having been earthed to the frame of the coil at the end of the first epoch of the survey, the second party used the electric coil No. 4 beside No. 3.

The Instruments.

The instruments used were the 1922 type of electric magnetometers with accessories for observation by Gauss-Lamont's method and dip circles. The theory of these electric magnetometers is given in "The proceedings of Physico-Mathematical Society of Japan, Nov. 1921", and in "Japanese Journal of Astronomy and Geophysics, Vol. I., No. 6, 1924". These magnetometers were made in the Naval Arsenal of Tôkyô from home-made materials including the glass for the objectives of astronomical telescopes, except the phosphor-bronz wire for suspension in the galvanometer. All such materials were tested with special care as to their non-magnetic properties.

(1) The Dip Circles.

The dip circles were of the usual types made by Casella and Dover, and the needles were replaced with new ones supplied by the Cambridge and Paul Scientific Instrument Co. The dip circles were adjusted in field by means of the theodolite in case of necessity according to the instruction shown on p. 20. The polarity of the needle was changed in the magnetizing coil with an electric current fed from a battery of 5 or 6 dry cells.

A galvanometer for the electric magnetometer is attached to the rectangular case of the dip circle with a counter weight (see Fig. 14), when observing horizontal intensity.

(2) Electric Magnetometer of 1922 Type.

This is a magnetometer-theodolite used for the determination of

declination and for the observation of horizontal intensity by the electro-magnetic method and astronomical observations. It is also used with certain accessories as an unifilar magnetometer for the observation of deflection and vibration by Gauss-Lamont's method.

The electric magnetometer consists of a theodolite, mirror magnetometers, an electric coil, a standard for current and some electrical accessories.

(a) *The theodolite.* The theodolite is shown in Fig. 1. The diameters of the azimuth and altitude circles are 13.9 cm., both graduated to 10′, reading to 10″ with two micrometers. The micrometric screws are of phosphor-bronze instead of steel to get rid of their magnetic effects. The telescope is of the "L" type to facilitate the transit observation with Y's of a small height. Its objective is of 5 cm. aperture and 27.5 cm. focal length, which makes it possible to obtain the image of the star even in twilight. To strengthen the structure, Y's are cast in one piece with the spindle of the horizontal circle and have a height of only 8 cm.

(b) *The mirror magnetometer.* The mirror magnetometer and its stage are made after the same design as those used in the previous survey, with certain improvements introduced to facilitate its manipulation and to adopt it for the determination of horizontal intensity by electric method. The principal differences consist in the reduction of the height of the stage and the attachment of two mirrors to the hanging magnet. The case containing the mirror magnetometer is of the same construction as the previous one. [1] The magnet is a small hollow cylinder, 1 mm. in diameter, 3mm. in length, made of K. S. magnet steel supplied by Messrs. Sumitomo & Co. of Osaka. This is mounted on a thin duralmin frame and suspended with a spider's thread. To this frame, two thin circular plane mirrors each 5 mm. in diameter are attached. The magnet and mirrors are shown in Fig. 2. The plane of the upper mirror is perpendicular, and that of the lower parallel to the axis of the magnet. The upper mirror serves for the adjustment of the coil and the observation of deflection, and the

(1) "*Bulletin of the Hydrographic Office, Imperial Japanese Navy, Vol. II*" p. 18

lower for the observation of declination. Two brass discs both 5 mm. in diameter are provided at the same heights for each mirror. Each disc may be pushed just behind each mirror to damp the oscillation of the magnet and to prevent twisting the spider's thread by turning the screw thread, which is attached to the back of the disc, from outside the case. The hanging magnet and mirrors, when not in use, are clamped to the magnetometer frame by means of clutches. Two spare mirror magnetometers are supplied to each instrument.

The magnetometer case is inserted in a tubular receptacle and is clamped by the screw thread S. The receptacle, indicated by F in Figs. 3 and 4, is on the upper plate of the double disc D D′, which form the stand of the case and fit to the top of the stage. The discs abut against each other in conical-hole-and-sphere contact W, and are tied by three screws P's, which serve to adjust the case into an upright position.

The stage consists of the base plate and the telescope holder. The base plate U stands on the three foot-screws L's, which fit into V grooves cut on the top plate of the theodolite, and are tied to the center of the plate by the screw T′, which may be turned by a screw driver through a vertical hole, before inserting the mirror magnetometer case into the stage. It has a vertical flange C, which is embraced by the tubular flange C′ of the telescope holder. By this means, the telescope holder may be turned around the flange C of the base plate and clamped at any azimuth by means of the screw S′ with a long handle.

An auto-collimating telescope TT′ with an objective of 12 mm. aperture and of 80 mm. focal length is provided with a glass scale σ of 1/10 mm. divisions at its focal plane. The central division of the glass scale is long and its image reflected on the hanging mirror can be seen on the glass scale itself in the field of view of the telescope. This telescope is attached to the holder by means of a rack-and-pinion RR′ and a pivot-and-Y's Y. The former serves to adjust the height of the telescope and is fixed by the screw H, while the latter serves to adjust the altitude of the telescope and is fixed by the screw A. Around the flange C′ of the holder, a ring B is fitted by means of a screw S″ with a long handle. To this

ring, a plate Q with an U shaped plate at its tip is hinged at h. On the flange C′, the lower flange of the disc D′ of the stand is inserted, and its position is adjusted by means of four screws s, s', s'', and s'''. The U shaped tip of the hinged plate is to be fixed to a small tongue T in Fig. 6, fixed to the clamp screw of the horizontal circle of the theodolite.

There are two ways of setting the telescope. The first is to fix it to the top plate of the theodolite, the second to horizontal circle. For the first, the U shaped plate Q is turned over as shown in Fig. 6, screw S″ is released, and the screw S′ is tightened. Then the telescope holder is secured to the flange C of the base plate U, so that the telescope may be turned with the top plate of the horizontal circle or Y's of theodolite. For the second, the U shaped plate Q is turned down and it is fixed to the tongue T by means of two screws J J′ as shown in Fig. 7. And the screw S′ is released and the screw S″ is tightened. Then the telescope is fixed to the clamp of the tangent screw of the horizontal circle, and does not move with the top plate of the horizontal circle or Y's of the theodolite, which is turned by the tangent screw. These settings can be easily understood from Fig. 5.

(c) *Helmholtz's coil.* The principle involved in the measurement of horizontal intensity by the electric magnetometer is to measure the angle of deflection in the sine method. This deflection is produced by a constant current, which is sent through the coil. Helmholtz-Gaugin's coil is adopted to obtain as great a space as possible for the uniform magnetic field due to the electric current. The electrical constants of the coil and current are determined before and after the survey. This coil is also used for the determination of declination according to Prof. Tanakadate's method.

(i) *Dimensions.* Considered from various points of view, the precisions of one gamma (10^{-5} c. g. s.) for horizontal intensity and of 5″ for declination may be sufficient for the magnetic survey, while the mean value of horizontal intensity of our surveying region is about 30,000 gammas. The space in the coil, where the hanging magnet is placed, should be a sufficiently uniform magnetic field with these precisions when a current is sent through the coil. Half the length of the hanging magnet

being 1.5 mm., this space may be a sphere of 3 mm. radius allowing for 1.5 mm. eccentricity of the magnet setting from the center of the coil. Such a setting may be easily effected according to the construction and adjustment of the coil. On the other hand, Prof. H. Nagaoka gave the following formulae for field intensity of a point near the center of Helmholtz-Gaugin's coil. [1]

$$X = i\frac{2304}{625\sqrt{5}\,a^5}xy(4y^2-3x^2)$$

$$Y = i\frac{32\pi}{5\sqrt{5}\,a}\left\{1+\frac{18}{125}(8y^4-24y^2x^2+3x^4)\frac{1}{a^4}\right\}$$

where a means the radius of the coil,

X means the perpendicular component of field intensity at a considered point due to the current i of the coil,

Y means the axial component of the same,

x is the distance of the point from the axial line of the coil,

y is the distance of the point from the central plane of the coil.

For the precision of 1 gamma for 0.3. c. g. s., the second term in the bracket of Y should be less than $10^{-5}/0.3$. For the deviation of field direction less than 5″, X/Y should be less than arctan 5″ or 24×10^{-6}.

In our case, the mean diameter of the coil should accommodate to the heights of Y's, which are 15 cm. about. The diameter of the coil designed is 12 cm. A diagram showing the variation of the axial component of the magnetic field in the region near the center of the coil is shown in Fig. 8. The variation perpendicular to the axial direction is shown in Fig. 9. From these figures, we see that a coil of 12 cm. diameter gives an ample space for the hanging magnet with the prescribed precisions. The uniformity of the field in the center region of the coil was easily proved by the experiment described on p. 20.

(ii) *Construction.* The frame of the coil is of cast duralmin. Its essential feature is two circular discs D D′ connected with three bars B B′ and B″ as shown in Fig. 10. Along the edges of D D,′ grooves G G′ of a rectangular section are cut, and the wires are wound

(1) *H. Nagaoka, "Magnetic Field of Circular Currents." Phil. Mag. [VI] 41. (1921), 387.*

in these grooves. Two pivots P P′ project perpendicularly from the centers of the discs. These pivots are placed on Y's of the theodolite when taking observations. The pivots and the grooves were turned on a lathe without dismounting them to avoid possible eccentricity. The parallelism of the magnetic axis of the coil and the axis of the pivots is nearly perfect, the deviation being less than 1′ for every coil. The diameters of the pivots are the same as those of the astronomical telescope of the theodolite. Holes H, H′ of 2 mm. diameter run through the axis of the pivots. By looking through these holes, the position of the hanging magnet is ascertained. The inner surface of the grooves are painted with enamel lack. Well-enamelled copper wire(1) of No. 30 S. W. G. is wound in the grooves of the frame, with a tension of 0.7 kg.. This tension is necessary to prevent the wire getting loose through its expansion due to temperature. The number of layers is 14, each layer consisting of 13 turns making 182 turns in each loop(2) fulfilling very nearly the requisite condition for eliminating G_3 of Maxwell's expansion, i. e., $13/14 \doteqdot 0.928 \doteqdot \sqrt{31/36}$.(3) Two wires are wound side by side to facilitate the insulation test. Terminals of the wires are connected to a brass pieces R fixed on the ebonite block E attached to the frame. Two wires wound in a groove are connected in series by connection of the brass pieces. To protect the wires from humidity, they are painted with enamel after being wound and covered with cotton cloth. The leading wires consist of a silk-covered stranded chord and are connected to the brass pieces of each loop. They are enclosed in a rubber tubing of 2 meters length. At first, a chord consisting of 15 wires of No. 30 S. W. G. was used. But, it was very soon found that such a thick chord is liable to break through folding and unfolding it during transportation, and in consequence a thinner chord consisting of 15 wires of No. 40

(1) *Before winding on the coil, a sample of the wire was wound on a cylinder of a few centi-meters radius and the insulation and flexibility of the enamel was tested by dipping this wire in water.*

(2) *To avoid ambiguity, let us designate each of the two coils constituting the Helmholtz's coil by the term "loop".*

(3) *Maxwell. "A Treatise on Electricity and Magnetism", Vol. II. 3rd. edition p. 357.*

S. W. G. was used. Both loops are connected in series by means of the switches at the ends of the leading wires. The terminals on the ebonite block are guarded by thin aluminium plates A, A′. The number of the coil is marked on one side of the frame, and this side is always set to the east when observing the horizontal intensity.

When the coil is put on Y's, two metallic holders M, M′ (see Fig. 11) are put on the tops of Y's. Between these holders, the coil is pushed to the right hand side always by a phosphor-bronz helical spring situated between the pivot P′ of the coil and the left holder M′. And the coil may be displaced along its axis with a travel of about 5 mm. by turning a screw S. By this arrangement, the center of the mean plane of both loops of the coil may be adjusted to coincide with that of the hanging magnet. The holes 3 mm. in diameter are bored in the holder and the screw S to enable the hanging magnet to be observed through the axis of the coil.

(d) *The standard of current.* The current sent through the coil is standardized and kept constant by the potentiometric method. For this purpose, we use standard resistances and standard cells, which are immersed in the transformer oil contained in a portable vessel. This is called the standard of current.

The standard cell is a cadmium cell of H type, the e. m. f. of which is 1.018 volt ca. The values of the standard resistances, which are shunted with the standard cell and a galvanometer are designed from the following considerations.

Since the deflection is observed by the sine method, its sensibility increases with the angle of deflection, which, however, must not be pushed too near 90°, to secure stability. Taking the required precision to be 1 gamma for 10″ i. e. the smallest readable angle of horizontal circle of the theodolite, the angle of deflection comes to about 55.°5 for $H=0.3$ c. g. s.. The electrical constant of the coil, i. e. field intensity at the center of the coil due to the unit current of the coil, is about 27.4 gauss per ampere, calculated from its dimensions and the number of the turns. A diagram showing the relation between the horizontal intensity and the

angle of deflection for several values of field intensity K_1 at center of the coil due to current is shown in Fig. 12. We can easily calculate the value of the standard resistance for every value of field intensity due to the coil by the following equation,

$$\text{standard resistance} = \frac{27.4 \times 1.018}{\text{Field intensity due to coil}}.$$

The resistances corresponding to every value of the field intensity due to the coil are given along the curves in the figure. From this figure, it will be seen that one standard resistance, or one constant current in the coil is not enough to cover observations through the whole area of Japan, where the horizontal intensity varies between about 0.4 and 0.2 gauss, assigning the angles of deflection to be between 40° and 70.° The suitable values of standard resistances are found to be 165 and 265 ohms. These values are obtained by having two standards of 100 and 165 ohms, which give 265 ohms when they are connected in series. These resistances are marked R_1, R_2, and R_3 respectively. The resistances are of silk-covered manganin wires wound on a micanite plate of rectangular form of about 12×6 cms.. The micanite plate is put aside the standard cells in transformer oil. The leading wires of the standard resistances are thick copper chords. The temperatures of maximum resistance of standard resistances were about 35°C., a little higher than expected.

Three standard cells are used. They are all of a saturated type of H form supplied from the Tôkyô Electric Co., Kawasaki. The first cell is used for an approximate adjustment of the current, the second for the actual measurement, and the third is a spare. These are marked C_1, C_2, and C_3 respectively. With these three, the deterioration of any one of them can be found by measuring the horizontal intensity with each cell, like three chronometers on board a ship. These cells are attached to a frame made of thin brass plates, and placed upright in transformer oil. Leading wires are bare copper chords, passed through the holes of glass beads for flexible insulation.

The standard resistances and cells were immersed in transformer oil, contained in a thin brass case with a thick ebonite cover. There is an

air space of 3 cms. between the surface of the oil and the ebonite cover for heat insulation. The brass case is protected with an alminium case, which is put in a wooden box of a size of $20 \times 10 \times 16$ cms. ca. in turn. For heat insulation, the space between the alminium and wooden cases is packed with cotton or felt. In colder climates, a small pocket warmer made of copper is put in this space to prevent the excessive cooling of the standard cell. The box is carried by the observer himself. The oil was stirred occasionally with a stirrer, and the temperature is read by a thermometer attached to the ebonite cover, the bulb being dipped in the oil. The time lag of the value of the current with respect to the thermometer indication, was hardly appreciable for the temperature fluctuation of 5°C. per hour, according to laboratory experiments.

Two plug switches of quadrantal form are attached to the inner side of the cover of the wooden box, one for standard resistances, and the other for the standard cells. The connection is shown in Fig. 13. Terminals marked E_+ and E_- are connected in the circuit between the coil and the dry cells, which feeds the coil. The terminals marked G_+ and G_- are connected to the terminals of a galvanometer (see Fig. 16.). By inserting a plug in one of the holes marked R_1, R_2, or R_3 and another plug into one of holes C_1 or C_2, we can obtain any combination of the resistances and cells. For example, by putting two such plugs into R_3 and C_2, the resistances of 100 and 165 ohms are connected in series, and the resulting 265 ohms is shunted by the cell C_2 and the galvanometer. To use the spare cell C_3, the leading wire of the cell C_1 is disconnected from the switch, and two plugs are put into the holes C_1 and C_3.

(e) *Electrical accessories.* A galvanometer of the Broca type was used. This galvanometer is attached to a wooden case of the dip circle with a counter weight W as shown in Fig. 14. The galvanometer needle is suspended by a thin phosphor-bronze strip, and its deflection is controlled by turning the torsion head H. To observe the deflection of the needle, an auto-collimating telescope T of the same type as that of the mirror magnetometer is used. The altitude and azimuth of the telescope may be controlled and fixed by the screws s s'. The sensibility of the

galvanometer is so made that the deflection of one division of the telescope of the galvanometer corresponds to the variation of the deflection one division of the auto-collimating telescope of the hanging magnet. The galvanometer should not be made too sensitive for the convenience of control. The needle of the galvanometer is lifted a little by pushing up the hanger button $\measuredangle$ and arrested by pushing in the arresters A, A′, when not in use.

The rheostat for regulating the current through the coil is made like that of the K-type potentiometer of Messrs. Leeds, Northrup & Co.. The two ebonite rings, on which resistance wires are wound, are attached to the back side of the cover of a box of dimensions $1 \times 6 \times 10$ cm. made of ebonite. (Fig. 15.) To one side of the box are attached six contact points provided with a sliding handle H, by means of which approximate adjustments of the current are effected, and succeeding finer adjustments by the handles A and B, connected to the sliding contact of the resistor wires. Terminals T and T′ are connected between the coil and the dry battery. (see Fig. 16.) Besides the above, two plug switches S S′, as shown in Fig. 13 were provided for the pole changers.

For observations by a single observer, the hanging mirror magnet may be used as a magnet of galvanometer.[1] But, this was not used in our case, because an assistant was always working with the observer.

(f) *General connection.* The general electrical connection is shown in Fig. 16. A battery B, consisting of 2 or 3 dry cells, feeds the current. The current from the battery is adjusted by the rheostat R. The direction of the current in both loops C and C′ of the coil may be changed at the same time by the pole changer S. The direction of the loop C′ may be changed by the pole changer S′. Then the current passes through the current standard, by which its prescribed value is ascertained.

(3) Unifilar Magnetometer.

Since a travelling survey by means of an electric magnetometer was our first experience, and perhaps of the world, we dared not start the survey with an electric magnetometer only. Consequently several accessories

(1) "*Japanese Journal of Astronomy and Geophysics. Vol. I, No. 6. 1924.*" *p 195.*

were added to make observations by Gauss-Lamont's method by changing it into unifilar magnetometer. But from the results of the survey we could unhesitating by affirm that the electric magnetometer proved quite reliable and very convenient during the first epoch of the survey, so that Gauss-Lamont's method was practically abandoned in the second epoch. A brief description of the accessories used will be given here.

(a) *Vibration magnet.* The vibration magnet M (Fig. 17) is a hollow cylinder of K. S. magnet steel, 0.9 cm. in diameter and 8.2 cm. in length. As in the Kew type magnetometer, the magnet is inserted into a brass collar C, having a lens at one end and a graduated glass at the other. This is suspended in a vibration box shown in Fig. 18 B with a phosphor-bronze strip. To the brass collar, the other brass tube C′ in Fig. 17 is attached to embrace a standard bar of a moment of inertia S. The vibration box is $11 \times 7 \times 7$ cm. in dimensions and is provided with a pair of brass pivots P and P′ on its two sides. These pivots are put on the Y's of the theodolite, and the box is supported by an adjustable foot screw S. The vibration of the magnet is observed with the auto-collimating telescope T of the mirror magnetometer through the glass covered window W of the box. A thermometer Th enclosed in a glass tube serves to read the temperature in the box. The K. S. magnet steel has a small temperature coefficient for magnetic moment, so that the correction for H due to difference of temperatures for the observations of vibration and deflection is much smaller than that for the usual magnet bars. The following table shows a comparison with the bar used in the previous survey.

Instrument.	Temperature coefficient of magnetic moment of bar.	Correction of H divided by H per 1°C. of temperature diff.
No. 2.	0.000173	0.000087
No. 3.	0.000196	0.000098
Instrument used in the previous survey.	0.00072	0.00036

Through the smallness of the coefficient, it was found impossible to determine the temperature coefficient from the field determinations of the

magnetic moment as in the previous survey,[1] and a special measurement had to be made in the laboratory.

(b) *Deflection bar.* The deflection bar (Fig 17 D) is of the same form as that of Prof. Tanakadate. It is made of bronze. The bar with two cylindrical parts P P′ is placed on the Y's. The case of the mirror magnetometer projects through the central hole H as shown in Fig. 19. The vibration magnet is placed in the groove G or G′ of the deflection bar. By contact of one end of the magnet with one end of the groove, the distance of the vibration magnet from the hanging one is determined. Contacts with each end of the groove give the two distances for the deflections. The grooves are cut to give deflections of about 7° and 15° in a field of 0.3 c. g. s. . To prevent the bar from bending, the ridges R R′ are provided. The deflection of the hanging magnet is observed by auto-collimating telescope T as shown in Fig. 19.

Instructions for the use of the Instruments.

(1) Astronomical Observations.

All processes of observations followed in this survey were the same as those of the previous survey, except the part simplified by the adoption of the electric magnetometer, which were fully followed especially in the second epoch of the survey. No further comment is necessary here as to astronomical work.

(2) Observation of Declination.

(a) *Setting of the instruments* :—Set the theodolite and adjust it in the usual way. Put the mirror magnetometer and its stage on the theodolite and fix them. Then fix the telescope to the top plate of the horizontal circle (see p. 6).

Mount the Helmholtz's coil on the Y's with the marked side set east and support it with the two holders M M′ (Fig. 11). Adjust its axis in an approximately east and west direction. Connect the rheostat, the two pole changers, and the dry cells as indicated by the diagram shown in Fig. 16.

(b) *Adjustment of the magnetometer* :—Set the mirror magnetometer vertical by means of the screws P's in Fig. 4 if necessary, and release

[1] *See ibid., p. 50.*

the magnet from its clamps. Turn the screw-threads attached to the brass discs behind the hanging mirror to adjust the positions of the discs in such a way that the upper disc is kept slightly apart from the upper mirror and the lower disc from the edge of the lower mirror. By sighting through the holes of the pivots, the hanging magnet is centered with regard to north and south by means of the screws s', s''' in Fig. 4 and its height is adjusted by means of the suspension nuts of the spider thread.

Adjust the auto-collimating telescope in such a way, that the reflected image of the scale on the central line of the upper mirror is clearly visible in the field of view. Send the current into the coil so that the currents in the loops C and C′ in Fig. 16 flow in opposite directions. If they do not, the magnet will deflect considerably. In this case, the current in one loop C′ in Fig 16 will be reversed by means of the pole changer S′. Any deflection with opposite current in the two loops shows some eccentricity of the position of the hanging magnet with respect to the Helmholtz's coil. By looking in the auto-collimating telescope, the screw S in Fig. 11 of the holder M may be turned until there is no deflection of the image of the scale line through sending and stopping the current. This adjustment is a very delicate process, and the screw S should be turned very slowly.

(c) *Adjustment of the coil to the magnetic meridian*:—Turn out the screw of the upper brass disc behind the hanging magnet, and turn the theodolite very slowly, until the west pivot of the coil points approximately north and the reflected image of the central line of the scale on the lower mirror is seen in the telescope. The height and altitude of the telescope should be adjusted for this purpose. Turn in the screw of the lower disc till it is just behind the lower mirror. Change the direction of the current in the loop C′ by means of the pole changer S′ in Fig. 16. Look into the telescope, send the current through the Helmholtz's coil in the sense to strengthen the earth field, judging by the quickened motion of image in the telescope. Still keeping up the current, turn the Y's until the image in the telescope comes back to its original position i. e. the position for no current in the coil. If it is found impossible to turn Y's sufficiently

on account of the image going out of the field of view, turn the telescope with respect to Y's by releasing the screw S′ in Fig. 5 in the direction, in which the image has gone astray. Then try a second adjustment. When the image does not move through sending and stopping the current, reverse the whole current by means of the pole changer S in Fig. 16. Then the image will in most cases be deflected one way or the other. Adjust the current by the rheostat, if necessary, so that its period of oscillation is about 2 or 3 times that under the earth field alone. Fix the telescope to the horizontal circle (see p. 7), and let the image coincide with the middle scale. This may be done by a slow turning of the screws J J′ attached to the forked plate. By means of the tangent screw, turn the horizontal circle slowly, until the image remains unmoved by the sending and stopping of the current. This is the exact position of the coil, where its magnetic axis is in the magnetic meridian. Note the time and read the horizontal circle. Reverse the coil, that is to say, lift it and bring the north pivot over to the south, and repeat the experiment in order to eliminate the magnetic collimation of coil; and note the time of finishing the observation. Subtract 90° from the mean of these two observations to get the magnetic meridian.

The sensibility of the coil for declination by weaking the earth field should not be pushed too far. As a set of observations can be made in three to six minutes, a sufficient number of observations are made to enable the observer to trace the diurnal curve on the ruled portion in the field book, to check mistakes or to detect a magnetic storm, if it happens. (see p. 25)

(3) **Observation of Horizontal Intensity.**

(a) *With electric magnetometer.* Observations were always made with the help of an assistant observer.

(i) *Adjustment of the instruments.* Adjust the magnetometer as described in the paragraph (b) on the observation of declination. Fix the galvanometer into the wooden box of the dip circle with a counter weight W as shown in Fig. 14. By releasing the hanging magnet from the arrester A A′ and the hanger h, adjust the auto-collimating telescope so as to sight

the image of the central line of glass scale on the mirror. In this case the azimuth of the horizontal circle of the dip circle may be in any position. The azimuth of the hanging magnet is adjusted by the torsion head H to cause the image of the scale to appear in the telescope. Connect the galvanometer terminals with the terminals G_+ and G_- with a chord. All the terminals of the connection should be cleaned with fine emery paper and clean cloth. All connections of the electrical circuit are to be made according to the diagram of Fig. 16. An assistant observer may conveniently control the rheostat, the current standard and pole changers S and S′ while observing the galvanometer.

(ii) *Measurement of deflection.* Put the horizontal circle perpendicularly to the reading of the horizontal circle in determining the declination, auto-collimating telescope pointing north. Looking through the telescope of the mirror magnetometer, and turning it slowly on its holder, bring the image of the central line to the center of the scale, then fix the telescope on the top plate of the horizontal circle. Send the current in opposite directions through each loop. Put the handles of the rheostat into their proper positions, which are known from the foregoing observations. This sending of the current is made by putting plugs into the holes R_1, R_2, or R_3 of the switch of the current standard according to the intensity of the field, which may be estimated from the result of the previous survey. Looking through the telescope of the galvanometer, put a plug into the hole C_1 of the switch of current standard for a short time. If the galvanometer deflects, change the current by turning the handles of the rheostat. The operation is begun with the handle B in Fig. 15, which will cause a slight change of the current, then the handles A and H are turned successively. It was found unnecessary to turn the handle A at the same station. The handle H was turned only in the case of renewal of the dry battery. Test the deflection of the galvanometer again by plugging C_1 for a short time with each turn of the handle, and find the position when the galvanometer shows no deflection. If the galvanometer deflects in an opposite direction, on account of its turning being too much, the handle should be turned in an opposite direction.

The plug must not be put in the hole C_1 except for observing the galvanometer deflection. Change the current by the pole changer S in Fig. 16, then the mirror magnetometer will deflect into a certain direction. Turn the Y's of the theodolite, and bring the image of the central line to the approximate center of the scale in the telescope, after waiting a while till the mirror magnet settles. Then, adjust again the current, plugging the hole C_2 for a short time. When the assistant has obtained the correct current, he should make a sign to the observer, who is bringing the image of the central line of the mirror magnetometer into the center of the scale. When this image of the central line is on the center of the scale, while there is no deflection in the galavnometer, read the horizontal circle of the theodolite, and record the readings on the note book. Reverse the whole current in the coil by means of the pole changer S in Fig. 16, and read the deflection of the theodolite in an opposite direction in the same way as the above. Between these two deflections, read the thermometers attached to the current standard and the coil, and note the readings. If the deflection is too small or the hanging magnet is unstable owing to the deflection being too near 90°, the measurement should be made with another standard resistance.

The schedule of field note is shown here.

Place. Kakioka. Date. Oct. 15*th*. 1922. Observers.

	t_c	$=23.0$	t_b	$=24.7$	Ôtani
Temperature	Corr.	$=\ 0.0$	Corr.	$=\ 0.1$	Nagoya
		23.0		24.8	

		A. Vernier			B. Vernier		
Deflection	Dir.	249°	48′	25″	69°	47′	52″
	Rev.	107	10	30	287	7	35
	Diff.	142	37	55	142	40	17

Mean $=142°\ 39'\ 6''$

$\frac{1}{2}$ Mean or φ $=71\ \ 19\ \ 33$

(1) Log. K_{30} $=9.449949$ Cell No. 2 Time

(2) Log. $\sin\varphi=9.976513$ Resis. No. 1 16^h 20^m

(3) (1)—(2) $=9.473436$

Corr. c.	$=$	-26	REMARK
Corr. b.	$=$	-52	
Log H	$=$	9.473358	
H	$=$	0.297412	

The explanations of the terms used are given on p. 23. The time required for the observation was usually three minutes and a half. Sometimes, more than fifteen observations including computations were made in an hour. The precision and consistency of the instrument were sufficient to trace the diurnal variation of the horizontal intensity as shown in Fig. 20. During some observations of declination as well as horizontal intensity, the hanging magnet was moved up and down a few millimeters by means of the suspension nut, and the coil was moved a few millimeters axially by means of the screw S in Fig. 11. But no variation of the position of the central line in the field of observing telescope was found. This means the uniformity of the field due to the coil at its center is sufficient. (see p. 8)

(b) *With unifilar magnetometer.*

Observations are made in the same way as given in the report of the previous survey. It is not necessary to repeat the detailed instructions here.

(4) **Observation of Dip.**

(a) *Adjustment of instrument.* To adjust the dip circle with the theodolite in the field, the following instructions were given to the observers for reference in case of necessity.

N. B. When this adjustment cannot be made with instruments of certain constructions, leave such instruments intact.

(I) *Preparation.*

1. Put the theodolite on the tripod, and adjust it just in the same way as in making an astronomical observation.

2. Focus the objective for the nearest distinctly visible object with the eye-piece of the largest magnification.

3. Set the dip circle as near the theodolite as possible we can distinctly observe the dip circle with the telescope adjusted as in the foregoing operation.

4. The agate edges of the dip circle should be about 15 cm. lower than the pivots of the telescope of the theodolite.

5. Level horizontal circle of the dip circle.

(II) *Adjustment of the vertical circle.*

6. Put the plane of the vertical circle of the dip circle parallel to the line connecting the theodolite and the dip circle.

7. Focus the telescope to the upper edge of the vertical circle of the dip circle, and make the spider wire cross of the telescope fall on the image of the tip of the graduated side of the upper edge.

8. Turn the telescope about the pivots, and let the cross fall on the lower tip of the vertical circle of the dip circle.*

9. If the cross coincides with the graduated side, it shows that the verticality of the vertical circle is correct. If not, adjust the inclination of the vertical circle, until the upper and the lower edge coincide with the cross by turning the telescope about the pivots.

(III) *Adjustment of the microscope.*

10. Set the A vernier of the vertical circle of the dip circle to zero.

11. Put the needle on the agate knife-edges horizontally.

12. Focus the microscopes on the ends of the needle.

13. Illuminate the eye-piece of the A microscope with an electric lamp. The image of the spider wire of the microscope made by the objective glass of the microscope can be made visible in the telescope by a slight displacement of the needle end. The azimuth of the dip circle should be changed to make this.

14. Adjust the horizontality of the spider wire by means of the telescope in the similar way as in the operation No. 8.

15. In the same way, adjust the horizontality of the spider wire of B microscope, and also adjust it into the same height as that of A microscope. Keep the telescope to the same position.

16. Turn the microscopes 180° about its horizontal axis, and make the spider wire of A microscope coincide with the cross of the telescope.

17. See that the height of B microscope is the same as that of A. If it is not, correct half the difference by displacing the spider wire in the microscope, and the other half by changing the altitude of the telescope.

18. Turn the telescope into the spider wire of A microscope with the same altitude and adjust the spider wire to coincide with the cross of the spider wires of the telescope. Then repeat the operations Nos. 14—18.

(IV) *Adjustment of the agate knife-edges.*

---

* *The cross of the spider wires of the telescope traces a vertical line when the telescope is turned about its pivots, and a horizontal line when turned about its vertical axis. Thus the vertical and horizontal alignments of objects may be tested.*

19. Take off the needle from the knife-edges.

20. Change the azimuth of the dip circle so as to put the vertical circle of the dip circle parallel to the sight line of the telescope.

21. Focus the telescope to the front ends of both knife-edges, and bring both ends to the same height.

22. Turn the dip circle about the vertical axis through 90°.

23. In the same way as No. 14, adjust the heights of both ends of the front knife-edge to make them equal by the adjustment of the other end of the edge. That is to say, make the front knife-edge horizontal.

24. Turn the dip circle through 90° more about its vertical axis.

25. Make the height of the end of the back knife-edge equal to that of the end of the front knife-edge.

26. Make the spider wires of the microscopes horizontal, by illuminating the spider wires with an electric lamp and looking at them through the telescope. Read the verniers A and B.

27. Put the needle on the knife-edge, and make one end of the needle coincide with the spider wire of the microscope A. This may be done by using a permanent magnet bar or by other means.

28. By turning the microscope, make the other end of the needle coincide with the spider wire of the microscope B. Read the microscope B.

29. Return the microscopes to the position obtained in No. 26.

30. Turn the needle end to end without changing face to face.

31. Repeat the operations in Nos. 27 and 28.

32. If the mean of the readings of the microscope B in Nos. 28 and 31 is equal to that in No. 26, the heights of the knife-edges are correct. If not, the height should be corrected in the following way.

33. If the mean of the readings in Nos. 28 and 31 is higher than that of No. 26, lower the knife-edges. If higher, raise them.

(V) *Adjustment of Y's and lifters.*

34. Lift the needle so that its axle gets slightly above the knife-edges. And keep the needle nearly horizontal.

35. Adjust the position of the front Y displacing it horizontally and parallel to the vertical circle of the dip circle so as to see the needle ends equally distinctly with both microscopes.

36. By turning the verniers, make the spider wires of the microscopes vertical, illuminating them with an electric lamp and looking at them through the telescope. Read the verniers A and B.

37. Make the same operations as Nos. 27 to 31.

38. If the mean of the readings of the microscope B in No. 35 is equal to that in No. 36, the positions of Y's are correct. If not, they should be adjusted in the following way.

39. Move the Y's toward the mean position of the readings of No. 36. The displacements of both Y's should be equal.

40. Put the vertical circle of the dip circle perpendicular to the magnetic meridian, and set the needle free.

41. Observing the image of an object made by reflection on the surface of the needle, lift the needle with Y's, then put it on knife-edges freely. If the needle moves without causing any motion of the image, the adjustment is correct. If the image goes down with the lowering of the needle, lower the front Y. If it goes up, lift the front Y.

(VI) *Repetition.*

The above 41 operations should be repeated until correct adjustments are obtained.

Comparisons of the dip circles before making the above adjustment have shown the corrections of the instruments to amount to 2′ or 3′. By this adjustment, the corrections were reduced to less than a minute, which may be taken as experimental errors.

(b) *Method of observation.* Usually the magnetic meridian is determined by observing the vertical standing of the dipping needle and the dip angle is measured in the order indicated in the schedule.[1] In the regions near the equator, the magnetic meridian is determined by a magnetic compass, put on the wooden case of the dip circle.

(5) **Formulas adopted.**

(a) *Azimuth of Polaris.*

(b) *Azimuth and time by single altitude.*

The formulas for the above two are the same as those in the previous survey.

(c) *Horizontal Intensity.*

(i) *Electric magnetometer.*

Let C_{20} donote the electrical constant of the coil or field intensity at the center of the coil due to the unit current in the coil at 20°C;

C_{t_c}, the electrical constant of the coil at t_c° C, determined from reading of the thermometer attached to the coil;

p, temperature coefficient of expansion of the duralmin frame of the coil;

I_{20}, the electrical constant of the current standard at 20° C, that is,

(1) *See "Bulletin of Hydrographic office, Imperial Japanese Navy" Vol. II p. 39.*

the current strength which will cause no deflection of the galvanometer at 20° C;

I_{t_b}, the electrical constant of the current standard t_b° C, determined from the reading of the thermometer attached to the current standard;

q, temperature coefficient of the electrical constant of the current standard; and

φ, angle of deflection found by observation.

Owing to the tension given to the wires of the coil while being wound[1], the expansion of the wires due to temperature is the same as that of the duralmin frame. Since the electrical constant of a coil is inversely proportional to its linear dimension, we have;

$$C_{t_c}=C_{20}[1-p(t_c-20)],$$

and also,

$$I_{t_b}=I_{20}[1-q(t_b-20)].$$

The field intensity at the center of the coil due to electric current at observed temperatures is

$$\begin{aligned} C_{t_c}I_{t_b} &= C_{20}I_{20}[1-p(t_c-20)][1-q(t_b-20)] \\ &= K_{20}[1-p(t_c-20)][1-q(t_b-20)], \end{aligned}$$

putting $C_{20}I_{20}=K_{20}$, where K_{20} means the field intensity at the center of the coil at 20°.

Considering that our method is the method of sine, we have

$$C_{t_c}I_{t_b}/H=\sin\varphi,$$

or

$$H=\frac{K_{20}}{\sin\varphi}[1-p(t_c-20)][1-t(t_b-20)].$$

φ, t_c, and t_b in the right hand factors are observed in the field. The other terms are determined in the laboratory, and their logarithms are computed, Log. $[1-p(t_c-20)]$ and Log. $[1-q(t_b-20)]$ are tabulated as "Corr. c." and "Corr. b.", taking t_b, t_c as arguments.[2]

(ii) *Unifilar magnetometer.*

The formulas adopted are the same as those of the previous survey. No additional remark is required in this connection.

---

(1) *See p. 9.*

(2) *See p. 19.*

(6) **Actual Observations.**

The Polaris was observed for the azimuth, and the Sun for the time usually. Because it is not necessary that the time observation should be exact when using the electric magnetometer, and this saves much labour of the observer. During the first epoch of the survey, when we did not rely solely upon the electric magnetometer, the observers were kept very busy by observing the horizontal intensity by both methods, and also making the time observation for the exact correction of the chronometer. With the subsequent use of the electric magnetometer as a regular instrument, much labour was saved. They observed horizontal intensity about 10 times a day by the electric method. Declination was observed once in an hour during daylight and once in every two hours at night. Dip was observed three times a day.

After finishing the observations at a station, the results were sketched on a sheet of paper as shown below and sent to the office.

Station { Name Hônan; φ 34° 31′ 36″; λ 127° 15′ 00″

Obs.r { Y. Ôtani; K. Naygoya

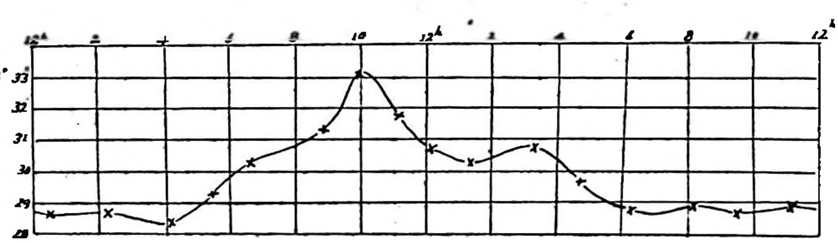
Note: Party II

Date: Nov. 27th–28th 1922

$\theta = 49° \; 21' \; 18''$

$\delta = \; 4° \; 29' \; 54.''4$

(on face of card)



Meridian: 353° 31′ 58.″7 by Calculation

H = 0.31272 (Gauss-Lamont's method)

	H	M	Mean Temp.	T	t_0	φ_1	φ_2	t_d	L.M.T.
(on face of card)	0.31266	420.94	11.23	6.4364	11.25	3°41′37.″6	8°11′6.″1	11.2	Nov. 27th 4h 50m
	0.31277	420.98	10.65	6.4347	10.90	3 41 41.4	8 11 20.4	10.4	" 5 20

H = 0.31277 (Electro-magnetic method) 電磁式水平磁力

	H	φ	Cell	Resis.	t_c	t_b	C. S. T.
	0.31284	64° 18′ 8.″5	C_1	R_1	14.0	12.0	Nov. 27th 12h 30m p.m.
	0.31287	" 17′ 14.5	"	"	15.0	"	12 35 "
	"	" " 17.0	"	"	"	"	12 40 "
	"	" " 09.3	"	"	15.2	12.1	12 50 "
(on back of card)	0.31292	" 11 16.8	C_2	"	15.8	12.2	1 0 "
	0.31295	" 10 53.0	"	"	16.0	"	1 5 "
	0.31293	" " 56.3	"	"	"	12.4	1 40 "
	0.31287	" 17 05.0	C_1	"	16.2	12.5	2 0 "
	0.31244	" 26 20.0	"	"	14.0	15.5	Nov. 28th 10 03 a.m.
	0.31246	" 28 45.1	"	"	15.0	16.1	10 18 "
	0.31272	" 14 26.3	C_2	"	16.0	17.0	10 26 "
	0.31271	" " 45.0	"	"	16.2	"	10 32 "
	0.31261	" 25 28.8	C_1	"	18.0	19.7	11 3 "

(Comparison) 比 較

	Coils	H	Cell	Resis.	Date
	No. 4	0.31282	C_1	R_1-R_2	Nov. 28
(on back of card)	"	0.31290	C_2	"	" "
	"	0.31261	C_1	R_1	" 29
	3	0.31211	"	"	" "

The standardization of the electrical constant of the coils was done at the end of the survey. The observers made the required computation by the provisional values of the electrical constants of the coils throughout the survey.

These sketches were narrowly saved from the great disaster of September 1, 1923. From the angle of deflection of the electrical magnetometer the observed values of horizontal intensity were obtained, in spite of that the standardizations of the coils were made at the end of the survey.

Standardization of the instruments.

Besides the field notes of the observations, all the records of the standardization including those of the electrical magnetometer, which was intended to be published in details in this report, were lost by the great fire. A brief sketch of the standardization of the electric magnetometer was published in the "Japanese Journal of Astronomy and Geophysics, Vol. I. No. 6, 1924," and its manuscript copy escaped the disaster by being kept in the Imperial University of Tôkyô. We regret very much that we cannot give the numerical values except those published in the said journal. The standardizations were made in the laboratory of the Central Bureau of Weights and Measures, with the assistance of the members of the Bureau. We wish to express our sincere thanks to Mr. Siryô Kikkawa, the director of the Bureau, for his kind permission to utilize its installation and to Messrs. Tokusaburô Tutumi and Kiyosi Sugimoto, members of the Bureau, with whose kind assistance the standardizations were completed.

(1) The electrical constant of the Helmholtz's coil.

The electrical source available in the field is the dry cell. The fairly constant current strength, which are obtained from a dry cell during an observation of about 3 or 5 minutes, are only a few centi-amperes. The decay of the current obtained from an ordinary dry cell was about 0.5×10^{-6} amp. per minute at the discharging rate of 10 m. a.. So, the available current from a dry battery may be about 10 milli-amperes. This was too small to give sufficient deflection for the observation of horizontal intensity with a coil of measurable dimensions, to which we could not give any large number of turns by reason of the difficulty of measuring its dimensions. This is the reason why we adopted a coil of 2×182 turns.[1] As it is difficult to calculate the electrical constant of a small coil acurately from its dimensions, we obtained it by comparing it by electric method with that of a standard coil, whose electrical constant is calculated from its dimensions.

To compare the electrical constant of a portable coil with that of the standard coil, the portable coil is put within the standard coil in such a way, that the centers and axis of the two coils coincide. A small magnet is hung at the common center, and the currents are sent into the coils in such directions that the magnetic fields due to each coil are opposite to each other. The ratio of the currents, when these magnetic actions become annulled at the hanging magnet, gives the inverse ratio of the electrical constants of the two coils.

(a) *The construction of the standard coil.*

The standard coil is a Helmholtz-Gaugin's coil of a single turn wound on a marble cylinder. A coil of single turn is adopted instead of one of many turns for following reasons.

(1) The construction is simpler.

(2) The measurement of its dimensions is easier.

It may, however, appear that a coil of single turn has the following defects.

(1') The correction of the end effect of the wire is not sufficiently small compared with that of the main part of the wire.

---

(1) *See p. 9.*

(2′) The wire of single turn can not carry a sufficiently strong current, to produce the required magnetic field, without causing some deformation of the coil.

As it will be explained afterwards, these defects were overcome and a coil of single turn was adopted. Its general feature can be seen from Fig's. 21, 22, and 24. A white marble block M is turned into a hollow right cylinder. The external surface is ground to a cylinder of a diameter of 20 cm.. The length of the cylinder is about 13 cm., its thickness about 3 cm.. The external and internal surfaces are ground on the lathe in single chucking to eliminate any eccentricity. Four circular holes H, H′, H″, and H‴ are bored at the middle of the cylinder 90° apart. On the external surface, two thin grooves are cut perpendicularly to the axis of the cylinder and 10 cm. apart. The depth of the grooves is such that the diameter of the central line of the wire loop wound in the groove would be 20 cm.. On the surface of each end of the cylinder, three alminium plugs P's of square form are inlaid with plaster of Paris. To these plugs are screwed the bolts B's to secure the covers to the cylinder.

Bare copper wires of an uniform diameter of 0.5 mm. are wound in the grooves G, G′. Special terminal blocks of ivory are made to give sufficient tension to the wires as shown in Fig. 23. A hole h and a groove g are made on an ivory block I of dimensions $5 \times 10 \times 10$ mm. ca. as shown in Fig. 23 A. A terminal of the wire is passed through the hole and bent as shown by the section given in Fig. 23 C. Two of these blocks are tied with three brass screws S's, with a thin mica plate M inserted between the blocks. By turning the screws S's, the wires are stretched in the grooves on the marble cylinder. The ends of the wires are cut a few centi-meters apart from the ivory block. These ivory blocks are laid in the rectangular cavities so that the center of the circular hole h is on the cylindrical surface of the marble.

Both ends of the marble cylinder are covered with the duralmin covers D, D′, which are secured with three bolts B's. On one side of each cover, the flange F is made to fit to the inner surface of the marble

cylinder. On the other side, the pivot P is projected. The pivot is hollow, and the duralmin covers are screwed to each end of the hollow space. Inner covers are the rings R, R', which just embrace the pivots of the portable coil. To one of the external covers, a screw S (Fig's. 22 and 24) is attached to displace the portable coil in the marble coil along their axes. Holes, 3 mm. in diameter, are bored through the axis of the screw S and the centers of the covers of the pivot to look through the axis.

(b) *The support of the coils.*

A special support is made of duralmin for the marble coil. A circular plate Pt of about 10 mm. in thickness is attached to the top plate of the horizontal circle of Kew pattern unifilar magnetometer as shown in Fig. 25. Y's, Y, Y' are attached to the circular plate Pt. The height of one of Y's may be adjusted by means of the screw s. To the outer sides of Y, two castings C and C' are attached. The pivots of the marble coil are to be mounted, on Y's between these castings C, C', and may be displaced axially by means of screw S' in Fig's. 22 and 24.

A triangular plate T, which fits on V grooves cut on the circular plate Pt with three screw foots, is screwed on the circular plate Pt. A cylindrical oil container Oc with a dove tail at its bottom fits to the triangular plate, and may be displaced perpendicularly to the Y's by means of screw N. On the top of the oil container, a mirror magnetometer case described on p. 5, is erected, being inserted between four thin plates e's soldered around a circular opening made on the top plate of the oil container. The bottom plate of the case of mirror magnetometer is then taken off, and a damper made of thin alminium, suspended from the lower end of the mirror magnet, passing through the bottom of the magnetometer case and the opening between springs e's, is dipped into the transformer oil contained in the container Oc.

To mount the coils for purposes of comparison, a portable coil is put in the standard coil by taken off the cover D. (see Fig. 24) A helical spring p made of phosphor-bronze is put between the cover c' of the pivot of the standard coil and a pivot of the portable coil. Pressing this spring with the portable coil, the cover D is screwed to the marble. The

screw S is screwed into the cover c of the pivot of the standard coil, so that the portable coil is held between the spring p and the screw S, its pivots passing through the rings R, R′. The marble coil is mounted on Y's of the support, and the case of mirror magnetometer is passed through the holes of the marble. The coils are mounted with the ivory pieces of the terminals of the wires of standard coil on the top. The marble coil is kept between the castings C, C′ attached to Y's by means of the screw S′ and the helical spring Q, around the screw S. Thus, the marble coil may be displaced axially by turning the screw S′ between Y's, while the portable coil may be displaced by turning the screw S in the standard coil. The axes of the screws S, S′ are bored about 3 mm. in diameter, so that the hanging magnet can be seen from outside through them.

(c) *The measurement of dimensions of the standard coil.* The quantities to be measured to compute the electrical constant of the standard coil are the diameter of each loop and the distance between the loops. Before measuring the dimensions, generating lines on the cylindrical surface were determined. For this purpose, the marble coil was placed on the support, and its axis was adjusted horizontal by means of striding level on the pivots, and the turning axis of the horizontal circle was adjusted vertical. A sighting telescope was put at a distance, at about the same height as the axis of the standard coil. By means of this telescope, two points of equal height, each near one loop of the coil, were determined by turning the coil around the vertical axis and marked with a pencil. The line connecting every two of these points is a generating line of the marble cylinder. These lines were marked at every 10° of the arch of the loops, making in total 36 generating lines. The eighteen diameters of each loop passing through these lines, and distances between the two loops along the thirty-six generating lines were measured.

The outer diameters of the loops were measured with an end-measure comparator measuring up to 1 meter, made by the Société Genevoise d' Instrument de Physique of Switzerland. The correction and the temperature coefficient of expansion of the scale attached to the comparator were studied by comparing it with a nickel standard scale No. 93, made by the said

Société, which was calibrated and studied with Meter Prototype No. 10(1874). The coil was placed on a thick glass plate, which is put on a leveling table with three foot screws, the plane of the loop being horizontal. This table was placed on the sliding table used for the comparison of the comparator. The outside diameter of the loop, near the ends of the generating line marked as described before, was measured by inserting the loop between the projecting studs of the comparator. By pressing one end of the diameter to the stud attached to the travelling scale of the comparator, the azimuth of the marble for the maximum length was found by turning it on the glass plate and as shown on the indicator of the comparator. The maximum length was also found by changing the inclination of the levelling table by means of its foot screws. This maximum length is the diameter. The distance between the loops and diameters of the wires of the loops were measured with a longitudinal comparator with two micrometers attached to the sliding table. The scale used was a platinum-iridium scale of 1 deci-meter belonging to the Bureau, standardized at the Bureau International de Poids et Mesures. By this means, the diameters of the cross sections of the wires of each loop and the distance between the loops were measured along every marked generating line. Both edges of each diametral plane of the wire were clearly visible in the field of the micrometer on the back ground of white marble.

Thus, we obtained the eighteen outside diameters of each loop of the coil. The mean diameter of the loop was obtained by subtracting the mean of the thirty six diameters of the wires of the loops from the mean of these diameters. The mean distance of the central lines of the loops of the coil was easily obtained. The probable fluctuation of these observed values including the error of construction were ± 6 microns ca.

The measurements were made in two different room temperatures, but the correction of the expansion of marble was negligible, because the difference of temperatures at the time of the measurement of the dimensions of the marble and at the standardization of the portable coil was very small, about 0.1° C..

(d) *Expansion coefficient of portable coil.*

To determine the temperature coefficient of expansion of the frame of the portable coil, three samples of duralmin of dimensions $7 \times 5 \times 100$ mm. ca were cut from the same material. Their temperature coefficients were determined by longitudinal comparator dipped in a water tank, at different temperatures. The mean of these three samples was adopted for p on p. 23.

(e) *The general arrangement for comparison of coils.*

The general principle of comparison is to find the ratio between the two currents, one flowing through the standard coil, the other through a portable coil, when their magnetic actions annul each other on a mirror magnet hanging at the center of both coils. The inverse ratio of the currents gives the ratio of the electrical constants.

For their comparison, the two coils were mounted on the support as shown in Fig's. 22 and 24. The electrical connection was made as shown in Fig. 26.

After levelling the support and the marble coil by means of a striding level and a screw s of Fig. 25, which correct inequalities of Y's of the support, the pivots of the coils were put in magnetic meridian, and the approximate position of the magnetic meridian was read on the horizontal circle of the support by sending a current to either coil, according to Prof. Tanakadate's method(1). We used a telescope attached to a stand to observe the deflection of the mirror magnet at some convenient position. By this reading, the axes of the coils were brought to the magnetic prime vertical. Looking through the boring in the axis of the coils, the height and the north south position of the hanging magnet were adjusted to the axial line by means of nut n and screw N in Fig. 25. A telescope and scale were put about three meters apart from the hanging magnet in the north direction to observe the deflection of the mirror. A clear view of the scale division in the telescope is very important, because the precision of the comparison chiefly depends upon

(1) *The difference of magnetic meridians obtained with each coil, i. e. the angle between the axial lines of each coil was very small. Its effects on the value of the ratio was found quite negligible.*

the reading of the scale as shown here-after. Sending the reverse currents to each loop of the standard coil, and displacing the standard coil on Y's by turning the screw S′ in Fig. 24, the coincidence of the hanging magnet and the center of the standard coil was obtained just in the same way as adjusting the portable coil in a field survey. After this, by sending the currents into the portable coil, the coincidence of the hanging magnet and the center of portable coil was obtained by displacing the portable coil in the rings R R′ of the standard coil by means of screws. By this means, the hanging magnet was brought to the common centers of both coils.

To facilitate the exchange of portable coils in the standard, the leading wires of the standard coil were connected with the wires of the coil with special connector s, the sections of which are shown in Fig. 27. A thin brass cylinder of 4 mm. diameter, and 10 mm. length, was cut through a diametral plane. An axial hole h or h' was bored near to its axis in each half. The diameter of the hole was slightly larger than that of the wire of the standard coil. These halves were squeezed into an ebonite ring R, a thin celluloid C being inserted between them. The tips of the wires of the standard coil were inserted into the holes h from below, and the end of the leading wires from above. To ensure good contacts, the surface of hole at both ends and the ends of the wires were amalgamized slightly. This connecting device was kept in its position by means of a screw S and aluminium frame A attached to a cover of marble cylinder as shown in Fig. 28. To eliminate small magnetic effects arising from the leading wire, rheostat etc., a compensating coil connected in series with the standard coil was used. The compensation was adjusted in the following way. Before standardization, the brass terminals of the coil were detached from the coil, and were short-circuited with short bare copper wires, which were inserted into the lower apertures of the holes of the connectors s, instead of the wires of the coil. This was kept just by the side of its position as shown in Fig. 28. About 15 amperes—5 times the amperage of standardization—was sent through the circuit. The compensating coil was put in such a position, that there was no deflection of the mirror magnet by making and breaking the circuit. The

magnetic effect on hanging magnet of the shifting of the brass terminals by a few milli-meters from their normal positions was quite neglegible. To calculate the end correction of the standard coil, X ray photograph of the ends of the wires in the short-circuited state and in their shifted position was taken. To take this photograph, a dry-plate was put between these end surface of the marble and the aluminium holder A in Fig. 28, and X ray was projected along a generating line of the cylinder. A picture so obtained is shown in Fig. 29. This correction is about 10^{-4} of the magnetic field due to the coil.

The diagram showing the connection for the standardization of the coil is given in Fig. 26. A potentiometer by Messrs. Leeds, Northrup & Co. was used.

A circuit of portable coil, consisting of an accumulator, a rheostat, a 100 ohms standard resistance, and two pole changers s s′, were all connected in series. The terminal of the standard resistance were connected to binding posts for a standard cell of the potentiometer, and a sliding contact for the standard cell was set at 1.01800 always. Two sets of Tudor type accumulators of 20 volts (capacity : 102 ampere-hours) were connected in parallel, and fed current to the standard coil through a standard resistance of 0.1 ohm, the rheostat, two pole changers S S′ and the compensation coil. The resistance of 0.1 ohm was immersed into a oil bath, stirred by a motor, and its terminals were connected to binding posts of e. m. f. of the potentiometer. The currents used were about 3 amperes for the standard coil.

It might be thought that 3 amperes is too strong for the wires of the standard coil. But no change in the dimension of the wire was perceived, when 5 amperes was sent through it, in measuring the diameter of the loop of the standard coil, the wires being insulated with thin mica plates from the measuring studs. (see p. 28.)

(f) *Procedure for comparison of coils.*

An assistant adjusted the current of the portable coil to about 10 m. a., then the current in the potentiometer was adjusted so as to give no deflection to the galvanometer, which was connected to 100 ohms

standard resistance. An observer adjusted the current in the standard coil so as to cause no deflection of the mirror magnetometer, put at the approximate center of the standard coil, while the assistant was measuring the e. m. f. of 0.1 ohm. The current in the standard coil was always changing, so that the assistant had to keep the galvanometer to zero by slowly rotating the drum of the potentiometer. When the galvanometer pointed to zero, the assistant gave a signal to the observer to read the scale of the mirror magnet, and himself read the potentiometer. At that instant, both circuits were cut simultaneously by means of two pole switches. Then the zero position of the mirror magnetometer was read. The difference in the reading of the mirror magnet before and after cutting the circuits gave the correction to the readings of the potentiometer by the assistant. In spite of variations of the current from the accumlators and of the earth magnetic field, the diagram showing this difference and potentiometer readings showed a fairly straight line. This means that the determination was reliable.

The ratio of the constants of the coils was given by the potentiometer reading divided by 0.00101800. The corrections of the potentiometer and the standard resistances were previously determined in Japan at the Electrical Laboratory of the Department of Commerce and at the National Physical Laboratory of England respectively.

To eliminate disturbances from tramcars, observations were made from 1^h to 5^h in the morning.

No's. 2,3, and 4 coils were standardized in the manner described above.

(g) *The allotment of errors in standardization of the coil.*

As it was explained already, the standardization consists from two procedures; i. e.

1. Determination of the constant of the standard coil.

2. Determination of the ratio of electrical contants of standard and portable coils.

The first is the measurement of diameters D and distance L of loops of the coil, and the constant K_0 is given by

$$(1) \qquad K_0 = 2\times 2\pi \frac{(D/2)^2}{\sqrt[3]{(D/2)^2+(L/2)^2}}$$

The second is the measurement with a potentiometer.

Let

K_0 be electrical constant of the standard coil,

K, electrial constant of the portable coil,

i_0 and i, the currents in the coils in case of comparison,

R_0 and R, the standard resistances, through which i_0 and i flow,

E_0 and E, the potential differences measured at terminals of R_0 and R,

r_0 and r, the resistances in the potentiometer for the potential differences of E_0 and E,

m, difference of the scale reading before and after cutting of the both circuits,

d, distance between scale and hanging magnet, and

H, horizontal intensity of earth field.

Or,

$$Ki = K_0 i_0 + mH/2d,$$
$$K = K_0 r_0 R/r R_0 + mH/2di,$$

Since,

$$i = E/R, \quad i_0 = E_0/R_0, \quad \text{and} \quad E_0/E = r_0/r.$$

This may be put

$$(2) \qquad K = \frac{K_0 r_0 R}{r R_0}\left(+1 \frac{mH}{2di_0 K_0}\right)$$

Among the terms of right hand side, K_0 is given in the equation (1). The accuracy of its determination depends upon that of the measurement of dimensions. This is in magnitude of 10^{-5} adopting the mean. r_0 R/r R_0 is the ratio of electrical resistances, and its precision was easily attained into 10^{-5}.

In the second term in the blacket, H/i_0K_0 is nearly equal to H/iK and is a value near unity. So, the accuracy chiefly depends upon $m/2d$. If we assume the minimum readable division of scale to be 1/10 mm., d must be $\frac{1}{2}$. 10^4 milli-meters or 5 meters to obtain the precision of 10^{-5}. But, it is not easy matter to get a readable division of 1/10 mm. at 6 meters scale distance, in varying earth magnetic field and with a

small mirror of 10 mm. diameter. On the other hand, the required precision to measure 1 gamma in 0.3 c. g. s. earth magnetic field, is 3×10^{-5}. So, we made the scale distance to be 3 meters. To increase the precision of the comparison, some special method to increase this precision of scale reading, e. g. to weaken the earth magnetic field at the center of the coils, or to use stronger stable current, should be imagined.

(*h*) *Comparison of the coils in the field observation.*

At Kakioka, all the three coils were connected in series, and magnetometer deflections of the three theodolites were observed simultaneously; and the coils were interchanged cyclically on each theodolite. From the results of these comparisons, we obtained the relative difference of the electrical constants of the coils, indepent of slight peculiarities of individual theodolites. On the other hand, Commander Ôtani observed the horizontal intensity with No. 3, and No. 4 coils at several of his stations during the second epoch of the survey. From these results, the relative difference of the constants of these two coils could be found.

(*i*) *The results of comparison and electrical constants of portable coils adopted for the survey.*

(I) Electrical constants of coils and their relative differences from No. 4 coil, by comparison with standard coil.

Constant of standard marble coil=0.0898668 gauss per ampere at 15° C.

Coils.	Electrical constant gauss per ampere reduced to 20° C.	Mean.	Relative difference.
No. 2.	27.3750		
	27.3766	27.3758	– 0.0738
No. 3.	27.3734	27.3734	– 0.0714
No. 4.	27.3019		
	27.3021	27.3020	....

(II) Relative differences of constants obtained by connecting them in series:

Coils.	Relative difference.
No. 1.	– 0.0979
No. 2.	– 0.0746
No. 4.	....

(III) Relative difference of constants obtain by Commander Ôtani's observations :

Coils.	Relative difference.
No. 3.	– 0.0729
No. 4.	....

Summing up the above results, relative differences with sespect to No. 4 coil are:

Coils.	By (I)	By (II)	By (III)
No. 1.	....	– 0.0979	....
No. 2.	– 0.0738	– 0.0746	....
No. 3.	– 0.0714	....	– 0.0729

Coincidence of the results of comparison were satisfactory. Thus, the constant of No. 1 coil was obtained by adding the difference obtained in (II) to those of the other coils obtained in (I). The final results are ;

Coils.	Electrical constants (Gauss per ampere) at 20° C.
No. 1.	27.3995
No. 2.	27.3758
No. 3.	27.3734
No. 4.	27.3020

(2) The electrical constant of the current standards.

To standardize the current standards of the electrical magnetometers, the current kept by the current standard to the correct value was sent through a standard resistance of 100 ohms, at whose terminals the potential differenco was measured with the potentiometer used for standardization of the coils. This gives the current strength kept by the current standard

L_{20} on p. 23, if it is reduced to 20°C. To determine the temperature coefficient, the standard with its brass case was immersed in an oil bath, and the current was measured at various degrees of temperature by heating and cooling the bath. No available chance was missed to make such observations.

The following shows the general results:—

Instrument.		October, 1922.	March, 1923.	Number of stations surveyed during these epochs.	Distance travelled by observer.
No. 1.	R_1C_1	1.01135	1.01122	14	12000 km.
	R_1C_2	1.01136	1.01138		
No. 2.	R_1C_1	1.01418	1.01353	28	4000 „
	R_1C_2	1.01419	1.01417		
	R_2C_2	0.62246	0.62249		
No. 3.	R_1C_1	1.03138	1.03074	28	5600 „
	R_1C_2	1.03218	1.03229		

The above value are those at 20°C. and given in centi-ampere. R_2 was used by No. 2 instrument only in Saghalin.

It should be noted here that the standard resistance of 100 ohms and the standard cell of the potentiometer, used to standardize the current standard, were standardized with the international ohm and the international volt. So, the current and also horizontal intensity given in the above is referred to the international ampere. But, the difference between international and absolute ampere seems to be

International ampere − Absolute ampere = −0.00009 ampere.

This means that the horizontal intensity to the absolute ampere or in gauss is smaller than that referred to the international ampere by as much as 9/100000.

(3) Several constants of unifilar magnetometer. The followings were determined for the unifilar magnetometer.

1. The dimensions and mass of standard inertia rod.
2. The moment of inertia of vibrating magnets.

3. The distances r_1 and r_2 of the deflection bar.
4. Coefficient of induction of the magnet.

These were determined in quite the same way as those in the previous survey. The numerical data, being lost by fire further remark is impossible here.

Comparison of the Instruments.

(I) *Comparison of the instruments of our observers.* Two satisfactory comparisons were made in October, 1922, in the middle of the survey, and in March, 1923, at the end of the survey.

In the October comparison, the observers were joined by a party with No. 4 of Prof. Tanakadate's magnetometer, which was used in the previous survey. For purpose of these comparisons, the observation tents of the all parties were pitched 10 meters apart on a straight line and named A, B, C, and D respectively. In March, 1923, the same points as in October preceding were occupied. All necessary operations were carried at signals, made by the inspector as soon as he was advised by signals that all the parties had finished the last setting of the instruments. To eliminate the variations of the magnetic elements due to the position of the tents, each party made observations in each different tent cyclically. In each tent, each party made six determinations of declination, five of horizontal intensity and two of dip.

(II) *Comparison of the instruments of ours and Chinese.* The comparison was made in the premises of the Lukiapang Magnetic Observatory in Nov. 1922. The instruments of the Observatory were also compared. The observations were made in the same way as described above. The stations used were Elliott pillar, Edmund's pillar, and Chree's pegs. No use, however, was made of the earth inductor of the Observatory, except its own pillar.

(III) *Comparison with the instruments of the Kakioka Observatory.* The comparison was made in Mar. 1923. Our instruments belonging to the Party II were operated on the stone pillars, on which the Observatory

instruments are usually used. The observed values were reduced to the same epoch as those of the Observatory instruments by the records of the magnetograph.

(IV) *Comparison with the instruments of the Carnegie Institution of Washington.* The comparison was made in Aug. 1922, when Mr. Brown of the Institution visited Japan.

(V) *The results of the comparison.* To our great regret, we can give only the following results. The values are given in gamma.

1. Comparison at Kakioka in October, 1922.

Observed values (Electric method by our magnetometer).

H=29600+........

Instrument \ Tent.	A	B	C	D	Correction referred to mean system of electric magnetometers.
No. 1.	84	102	82	75	3
No. 3.	106	89	115	66	–5
No. 2.	84	92	92	80	2
No. 4 of Prof. Tanakadate's.	85	101	107	52	3

Observed values (Gauss-Lamont's method of our instruments).

H=29600+........

Instrument \ Tent.	A	B	C	D	Correction referred to No. 4 of Prof. Tanakadate's.
No. 1.	25	75	76	32	17
No. 3.	73	81	98	71	–12
No. 2.	100	35	64	69	– 2
No. 4 of Prof. Tanakadate's.	93	81	46	56	—

2. Comparison at Kakioka in Mar. 1923.

Observed values (Electric method). H=29600+........

Instrument \ Tent.	A	B	C	Correction referred to the mean.
No. 1.	97	97	82	0
No. 3.	69	116	105	-4
No. 2.	99	62	103	4

3. Comparison at Lukiapang.

Observed value (Electric method for No. 1 magnetometer).
H=33000+........

Instrument. \ Spots.	Elliott's pillar.	Edmund's pillar.	Chree's pegs.	Corection referred to No. 1.
Elliott No. 49.	186	209	184	64
Chasselon No. 24.	223	222	233	30
No. 1 of ours.	278	259	234	....

From the observations with coils connected in series made during the comparison at Kakioka in March, the combined correction for the station and the theodolite, i. e. for the magnetometer excluding the coil may be computed. Subtracting the corrections of the stations from these combined ones, the corrections of the theodolite were found to be as follows;

No. I. Theodolite.	0.8 gamma
No. II. Theodolite.	0.2 "
No. III. Theodolite.	-1.0 "

These may be regarded as experimental errors.

Summing up the results, we have;

Correction referred to the mean system of the electric magnetometer, in gamma of absolute measure.

Instruments	August, 1922.	October, 1922.	November, 1922.	March, 1923	Mean
No. 1. (electric.)	....	3	....	0	2
No. 2. („)	......	2	......	4	3
No. 3. („)	......	–5	......	–4	–5
Tanakadate No. 4.	......	3	......	......	3
Kakioka standard.	......	......	......	0	0
Elliott No. 49 (Lukiapang)	......	......	66	......	66(1)
Chasselon No. 24. (Lukiapang)	......	......	33	......	33
I. M. S. of C. I. W.	11	......	......	......	11(2)
Sine galv. of C. I. W.	9	......	......	......	9(2)
Schuster-Smith's.	7	......	......	......	7(2)
No. 1. (Gauss-Lamont's method.)	......	20	......	......	20
No. 2. („ „ „)	......	1	......	......	1
No. 3. („ „ „)	......	–9	......	......	–9
Station at Kakioka. (referred to mean station.)					
Tent A.	......	3	......	4	4
Tent B.	......	0	......	0	0
Tent C.	......	–2	......	–5	–4

We have nothing to publish here in regard to declination and dip, but, their instrumental corrections did not exceed a few minutes.

(1) *I. M. S.—Lukiapang (Elliott's No. 49) = 57.9 (Oct.—Nov. 1917.) See "Research of the Department of Terrestrial Magnetism. Vol. IV. p. 445. Carnegie Institution of Washington. 1921."*

(2) *These are not much reliable. Because the comparison made in Aug. 1922 was unsatisfactory, and has needed a further operation.*

PART II.

REDUCTION OF THE OBSERVED VALUES OF MAGNETIC ELEMENTS TO THE EPOCH 1923.0 AND THE DEDUCTION OF THEIR EMPIRICAL EXPRESSIONS.

Data.

(1). Principal data.

The observed values of the magnetic survey for 1922-1923 constitute the principal data used in the computation of the empirical formulas given in the present bulletin.

(a) *The magnetic survey of Japan and Marshall, Caroline, and Mariana groups of islands.*

This survey was executed by the Hydrographic Department of the Japanese Navy during June, 1922, and August, 1923. Observations were made at 148 stations in all and the results are given in Table 1, in which the means of a series of observations are given as the observed values of the magnetic elements at each station. The values of Horizontal Intensity in the Table are reduced to the mean system of the instruments which were used in this survey. The instrumental corrections of Declination and Dip, of which all records were destroyed as stated before, were under two minutes at most according to the observer's memory. Since these corrections have only a slight effect upon the Secular Variations, we have neglected them in the computation of the Secular Variations.

The topographical sketches of the stations included in this survey are omitted from this bulletin, but preserved in this Department for future references. These were chiefly drawn by the observers from their memory by referring to the sketches prepared on the occasion of the preceding survey of 1913.

(b) *The magnetic survey of the Chinese coast.*

This survey was conducted by the Chinese Government during May, 1922, and February, 1923, the observations having been made by Mr.

Francois Lou. The summary results of the observations are given in Table 2, in which the means of several observations are given as the values of the magnetic elements at each station. The total number of stations observed is 18, of which 9 are among the former Carnegie stations.

(2). **Data derived from foreign sources.**

In order to extend the area for empirical formulas beyond the regions above mentioned, we adopted the following materials.

(a) *The land and ocean magnetic observations by the Department of Terrestrial Magnetism of the Carnegie Institution.*

(i) *Secular Variation of Declination.*

For the computation of the Secular Variation of Declination, all stations of repeated observations within the region extending from 60°N Latitude to 45°S Latitude and from 100°E Longitude to 130°W Longitude given in Vol's. I, II, and IV of the "Land Magnetic Observations" were included in the process. The number of such stations is 14 in all, and the name and the Secular Variation of Declination of each station are given in Table 8. and the latitude and longitude in Table 3.

Number of stations	Region.
9	China
5	Islands in the Pacific Ocean
Total 14	

(ii) *Declination and Dip on land.*

For computation of Declination and Dip, all observed stations within the region extending from 55°N to the equator and from 115°E to 175°E mentioned in Vol. IV of the "Land Magnetic Observations" were consulted. The number of such stations is 90 in all.

Number of stations	Region
85	China
5	Islands in the Pacific Ocean
Total 90	

As the stations in some parts of China are crowded together, we divided them into 6 groups for convenience of computation. The mean value of observations at each station of each group was taken for the value at the mean station of the group at the mean epoch, and the position of such station is given by the mean latitude and longitude of the stations in the group. The positions of the stations consulted and the mean stations are shown in Map IV and the positions and Declinations and Dips of such mean stations and the stations on the Pacific Island are given in Table 3.

(iii) *Declination and Dip on the ocean.*

For computation of Declination and Dip, all observations made on the ocean by the "Carnegie" Cruises II and IV within the region from 55°N to the equator and from 115°E to 175°E were taken from Vol. III of the "Ocean Magnetic Observations". The number of such observations is 351 in all. For convenience of computation, we divided the observations into 76 groups.

	Number of observations		
	Declination.	Dip.	Grand total.
Cruise II	66	49	115
Cruise IV	150	86	236
Total of Cruises II and IV	216	135	351
Number of groups	37	39	76

The positions of spots of observations and mean stations are shown in Map IV and the positions of the mean stations and the mean observed values at the mean epochs are given in Table 3.

(b) *Observations at the magnetic observatories in and around the Pacific Ocean.*

In order to study the Secular Variations of the magnetic elements in our region, we appropriated the materials of observations at 9 observatories in and around the Pacific Ocean from the "Terrestrial Magnetism and Atmospheric Electricity," the "Meteorological Reports," etc. The annual mean values are given in Table 4.

(3) **Data derived from other sources in Japan.**

(a) *The magnetic observations at the fixed stations in Japan.*

(i) *The Kakioka Magnetic Observatory.*

Latitude, 36° 13′ 51″ N; Longitude, 140° 11′ 21″ E; Elevation, 28.2 meters.

This observatory is attached to the Central Meteorological Observatory of Tôkyô and stands at a distance of about 75 *km.* north-east of Tôkyô.

The available records of the observatory were destroyed by the great fire of 1923.

(ii) *The weekly observations at the fixed stations.*

At the instance of this Hydrographic Department, observations are made 4 times on a fixed day of every week at the following 3 Meteorological Stations.

Meteorological Stations.			Elements	Year of
Name.	Latitude.	Longitude.	measured.	commencement.
Ôtomari	46° 38′ 46″N,	142° 46′ 17″E	Declination	1920
Zinsen	37° 29′ 54″N,	126° 37′ 36″E	Three elements	1918
Taihoku	25° 02′ 19″N,	121° 30′ 49″E	Declination	1919

The records of the Ôtomari and Taihoku stations were lost in Tôkyô in consequence the great fire, but those of the last station were duplicated and supplied by its Director Mr. Teramoto.*

(b) *The occasional observations in the course of hydrographic surveys by this Hydrographic Department.*

In most cases, observations were restricted to Declination only. The records of these observations were lost by the great fire, and the values extracted from "The Yearly Reports of the Japanese Hydrographic Department" are the summaries of such records.

The observations at Karahuto and Tisima are given in Table 5 and at Marshall, Caroline, and Mariana Islands in Table 8.

(*) *The annual mean values at Zinsen and Taihoku are given in Table 4.*

Number of stations.	Region
15	Karahuto (Sakhalin)
26	Tisima (Kurile Islands)
13	Marshall, Caroline, and Mariana, Islands

General Methods of Computation.

The empirical equations of Secular Variations were first found and all data were reduced to the epoch 1923.0, from which the empirical equations of magnetic elements were deduced and the mean isomagnetic lines drawn.

The computation of empirical equations was effected in two stages;

1st. Finding the general magnetic features of the entire regions.

2nd. Finding the local characteristics of restricted places.

(1) Finding general features.

We ascertained by rough calculations, that the three elements of terrestrial magnetism and their Secular Variations in a region for which we require empirical formulas may be roughly expressed in the form of quadratic functions of latitude and longitude. The empirical equations were therefore worked out as the quadratic functions of latitude and longitude by the method of least squares, thus;

$$M = M_0 + a\cdot\Delta\varphi + b\cdot\Delta\lambda + c\cdot\Delta\varphi^2 + d\cdot\Delta\varphi\Delta\lambda + e\cdot\Delta\lambda^2.$$

Where M is the elements of terrestrial magnetism and M_0, a, b, c, d, and e are the coefficients which are to be determined by the method of least squares, while φ and λ represent the north latitude and the east longitude, and $\Delta\varphi = \varphi - 35°$ and $\Delta\lambda = \lambda - 135°$ expressed in degrees.

(2) Finding local characteristics.

The formulas thus obtained may be considered to represent the general features of the whole region, but the area they cover is too wide to allow of their representing in detail the characteristics of special parts. Since any systematic distribution of the residuals, i. e., the surplus of the observed values over the values calculated by the above expression, may be considered to arise from the local characteristics. We marked such residuals over each station on the maps, and by studying their distribution we divided the whole area into a number of sections, in each of

which the residuals may be developed in a quadratic function of φ & λ, each of such sections being bounded by the line separating the maximum and the minimum of the residuals. Then the computation of empirical equations was effected by taking them as the quadratic functions of latitude and longitude, by the method of least squares. The stations near the boundaries of each section were taken into the calculation of the empirical equations of the two adjoining sections, and the isomagnetic lines were connected by the smooth curves at the boundaries of each section.

(3) Number of stations.

The number of the stations used in computation of the empirical equations, is tabulated below.

SECULAR VARIATION.

Number of stations.		Region	Date.	Observer.
Decl.	Horiz. Intens.			
4	4	Karahuto (Sakhalin)	1912-1922	Japanese Hydrographic Department
7	7	Hokkaidô	1912-1922	„
33	32	Honsyû	1912-1923	„
5	5	Sikoku	1913-1922	„
12	12	Kyûsyû	1912-1923	„
15	14	Tyôsen (Corea)	1912-1922	„
2	2	Ryûkyû	1912-1923	„
5	4	Taiwan (Formosa)	1913-1922	„
3	3	Ogasawara (Bonin Islands)	1913-1922	„
13		Marshall, Caroline, & Mariana Is.	1915-1923	„
22		China	1907-1923	Chinese Govern. & Carnegie Inst.
11		Pacific Islands	1906-1916	Carnegie Institution
132	83	Total		

The Secular Variation of Dip was not computed.

THE THREE ELEMENTS OF TERRESTRIAL MAGNETISM.

Number of stations.			Reigion	Observer.
Decl,	Dip	Horiz. Intens.		
21	15	6	Karahuto (Sakhalin)	Japanese Hydrographic Department
23	3		Tisima (Kurile Islands)	,,
12	12	12	Hokkaidô	,,
42	42	41	Housyû	,,
5	5	5	Sikoku	,,
14	13	15	Kyûsyû	,,
28	28	27	Tyôsen (Corea)	,,
4	4	4	Ryûkyû	,,
8	8	7	Taiwan (Formosa)	,,
7	7	7	Ogasawara (Bonin Islands)	,,
18	18	18	Marshall, Caroline, & Mariana Is.	,,
33*	31*	22	China	Chinese Govern. & Carnegie Inst.
7	7		Pacific Islands	Carnegie Institution
37△	39△		Pacific Ocean	,,
259	232	164	Total	

* 5 of these are the mean stations.

△ These figures show the numbers of the mean stations.

The General Aspect of the Secular Variations in the North Pacific Ocean, as Deduced from the Data Obtained from the Fixed Magnetic Observatories.

The annual means of the magnetic elements observed at the 11 observatories in and around the Pacific Ocean are given in Table 4, and their variations during 1902 and 1923 are shown in Fig. 30, 31, and 32.

Declination.

From the curves shown in Fig. 30, we see that there exists a considerable Secular Variation, varying with the position of the observatories. No Secular Acceleration after 1910 is observable except at the station at Sitka.

Dip.

The curves shown in Fig. 31, indicate that there is a considerable Secular Variation. of nearly the same extent at all observatories except Buitenzorg. Secular Acceleration is hardly appreciable at all observatories except at Honolulu like Declination.

Horizontal Intensity.

The curves shown in Fig. 32 are generally irregular and we note that the Secular Variation and Acceleration are also very irregular at all observatories except at those of Sitka, Honolulu, Apia, and Christchurch.

Conclusion.

The general aspect mentioned above, shows us that the Secular Variations of the Declination and Dip in the North Pacific Ocean can be obtained from the repeated observations of a few years apart, but not the Secular Variation of Horizontal Intensity. Moreover we notice that the Secular Variation of Declination varies with its position and has a systematic distribution in general, but the Secular Variation of Dip varies very slightly and irregularly with its position.

Declination.

(1) Secular Acceleration $\left(\left[\frac{d^2\delta}{dt^2}\right]_{\text{a year}}\right)$.

We have four complete magnetic surveys of Japan in 1887, 1896,

1913, and 1923. The first and second surveys were confined to Japan Proper, but the third survey was extended from Karahuto (Sakhalin) and Tyôsen (Corea) to Taiwan (Formosa), and at the fourth and last survey, the region was still more extended from the Chinese coast to Marshall, Caroline, and Mariana Islands. There are 14 stations, at which or very near to which observations were repeated four times, and 43 stations, where observations were repeated in 1896, 1913, and 1923. The observed values at the stations where observations were repeated four times are given in Table 6 and plotted in Fig. 33. Those at the stations thrice observed are plotted in Fig. 34.

The curves in Fig. 33 show that the considerable amount of Secular Acceleration, which made its appearance during the interval between 1887 and 1913, vanished after 1896. The curves in Fig. 34 also show the existence of a slight Secular Acceleration during 1896 to 1923, with the exception of a few stations. These facts agree with the data furnished by the observatories.[1]

The values of Mean Secular Acceleration obtained from the differences between the two Mean Secular Variations for the intervals between 1896 and 1913 and between 1913 and 1923, are given in Table 7. These values of Mean Secular Acceleration are small compared with those obtained in the interval between 1887 and 1913[2]. This shows that they have no appreciable effect on the extent of Mean Secular Variation.

(2) Secular Variation $\left(\left[\frac{d\delta}{dt}\right]_{\text{a year}}\right)$.

There are 109 stations where surveys were repeated twice in 1913 and 1923 and the values of the Mean Secular Variation of these stations are given in Table 8.

(a) *General features.*

As we ascertained by a rough calculation that the lines of equal Mean Secular Variation in the enlarged region from 60°N to 45° S and from 100°E to 135°W may be expressed by the quadratic function of latitude and longitude, we adopted the data supplied by the observatories

---

(1) *See page 53.*
(2) *See the Vol. II of the Bulletin of this Department.*

and 14 Carnegie stations in this region in addition to those of the 109 twice observed stations. The values of these various data are given in Table 4 and 8.

The empirical equation of Mean Secular Variation was computed by the method of least squares from the data of the 132 stations tabulated on page 51, each station having the same weight. The positions of all the stations are shown in Map I.

The result of computation is;

$$\left(\frac{d\delta}{dt}\right)_{1918} = 1'.829 + 0'.07460 \cdot \Delta\varphi - 0'.02462 \cdot \Delta\lambda + 0'.0004960 . \Delta\varphi^2$$
$$- 0'.0002088 . \Delta\varphi . \Delta\lambda - 0'.0003067 \cdot \Delta\lambda^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (1)$$

Where φ and λ represent the north latitude and the east longitude, and $\Delta\varphi = \varphi - 35^\circ$ and $\Delta\lambda = \lambda - 135^\circ$ expressed in degrees.

The lines of equal Mean Secular Variation are drawn in Map I by this expression.

The values of Secular Variation, observed and calculated by this expression and their residuals, are given in Table 9. The probable error of a single station of Secular Variation, based upon these calculations, is $\epsilon = \pm 0'.468$.

(b) *Local characteristics.*

To find out the local characteristics, we divided the whole region into three parts as shown in Map II.

Part I includes the northern parts of Japan.

„ II „ „ southern „ „ „ and China.

III „ „ „ „ „ „ Marshall, Caroline, and Mariana Islands.

In Map II, the Parts I, II, and III are enclosed by fine red, blue, and black lines.

The empirical equations of characteristics in each Part were computed by the method of least squares as the quadratic functions of latitude and longitude from the residuals of (1). In this calculation, the residuals of 5 stations which are marked † in Table 9, were excluded, because they may be considered to be abnormal. The numbers of stations, adopted in

the computation, are in Part I 65, in Part II 54, and in Part III 55.

The results of computation are

in Part I $r_I = 0'.213 - 0'.02317 \cdot \Delta\varphi + 0'.03594 \cdot \Delta\lambda + 0'.0054727 \cdot \Delta\varphi^2 + 0'.0033375 \cdot \Delta\varphi \cdot \Delta\lambda - 0.'0014408 \cdot \Delta\lambda^2$ . . . . (2)

" " II $r_{II} = -0'.130 - 0'.07971 \cdot \Delta\varphi + 0'.02418 \cdot \Delta\lambda - 0'.0050542 \cdot \Delta\varphi^2 - 0'.0023076 \cdot \Delta\varphi \cdot \Delta\lambda + 0'.0044477 \cdot \Delta\lambda^2$ . . . . (3)

" " III $r_{III} = 0'.506 + 0'.00157 \cdot \Delta\varphi + 0'.03519 \cdot \Delta\lambda + 0'.0001088 . \Delta\varphi^2 + 0'.0008679 \cdot \Delta\varphi \cdot \Delta\lambda - 0'.0006940 \cdot \Delta\lambda^2$ . . . . (4)

The lines of equal local characteristics are drawn on Map II from these expressions, the red, blue, and black lines referring to Parts I, II, and III respectively, and they are pecked thus - - - - -, where they project into another Part.

The first residuals[1] of (1), those calculated by the equations (2), (3), (4), and their second differences[2] are given in Table 10. The probable errors of a single residual, r_I, r_{II}, r_{III}, based upon these calculations are

in Part I $\varepsilon_I = \pm\ 0'.290$

" " II $\varepsilon_{II} = \pm\ 0'.351$

" " III $\varepsilon_{III} = \pm\ 0'.244$.

The lines of equal Mean Secular Variation which were obtained by adding the expressions (1) and (2), (3), (4), are indicated in Map III, in which the lines on the boundaries of the 3 Parts are connected by smooth curves.

(3) Declination for the epoch 1923.0 (δ).

(a) *General features.*

The entire materials tabulated on page 52, for the region, extending from 55°N to the equator and from 115°E to 175°E, were reduced to the epoch 1923.0 by the empirical expression of Secular Variation in the foregoing paragraph, as given in Table 11. From these reduced values, the empirical equation of Declination was calculated as a quadratic function of latitude and longitude by the method of least squares, each

---

(1) *These values are the differences between the values observed and calculated by (1).*
(2) " " " " " " " " " " " " " " (1)+(2), (1)+(3), or (1)+(4).

station being allowed the same weight.

The result of calculation is

$$\delta_{1923\cdot0}=5°18'.40+15'.2690\cdot\Delta\varphi-2'.1658\cdot\Delta\lambda+0'.027540\cdot\Delta\varphi^2$$
$$-0'.058470\cdot\Delta\varphi\cdot\Delta\lambda-0'.406110\cdot\Delta\lambda^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (5)$$

Where φ and λ stand for the north latitude and the east longitude, and $\Delta\varphi=\varphi-35°$ and $\Delta\lambda=\lambda-135°$ expressed in degrees.

All stations used in this calculation, are shown in Map V.

The isogonic lines in Map V are drawn by the above expression.

The values of Declination observed and calculated by the expression (5), and their residuals are given in Table 12. The probable error of a single observation of Declination, based upon this calculated, is $\varepsilon=\pm34'.04$.

(b) *Local characteristics.*

To find the local characteristics, we divided the whole region into the following three parts, as shown in Map VI.

Part I includes the northern parts of Japan.

„ II „ „ southern „ „ „ and China.

„ III „ „ „ „ „ „ „ Marshall, Caroline, and Mariana Islands.

In Map VI, the Parts I, II, and III are enclosed by fine red, blue, and black lines.

The empirical equations of the local characteristics in each Part were computed by the method of least squares from the residuals of (5). In this calculation the residuals of expression (5) of the stations in Kita-Karahuto (North-Sakhalin) and Tisima (Kurile Islands), and of 20 stations in the other districts which are marked † in Table 12, were excluded, being considered to be abnormal. The numbers of stations adopted in the computation, are in Part I 102, in Part II 64, and in Part III 111.

The results of computation are;

in Part I $r_I=16'.14+3'.8480\cdot\Delta\varphi+0'.3847\cdot\Delta\lambda-0'.115902\cdot\Delta\varphi^2$
$$+0'.098700\cdot\Delta\varphi\cdot\Delta\lambda-0'.270180\cdot\Delta\lambda^2 \quad . \; . \; . \; . \; . \; . \; . \qquad (6)$$

„ „ II $r_{II}=10'.34+6'.5458\cdot\Delta\varphi+1'.3863\cdot\Delta\lambda-0'.106129\cdot\Delta\varphi^2$
$$+0'.593059\cdot\Delta\varphi.\Delta\lambda-0'.007364\cdot\Delta\lambda^2 \quad . \; . \; . \; . \; . \; . \; . \qquad (7)$$

in Part III $r_{III}=8'.93+5'.9069\cdot\Delta\varphi-4.'7571\cdot\Delta\lambda+0'.116153\cdot\Delta\varphi^2$
$-0.'245940\cdot\Delta\varphi\cdot\Delta\lambda+0'.071541\cdot\Delta\lambda^2$ . . . . (8)

The lines of equal local characteristics are drawn on Map VI from these expressions. The red, blue, and black lines refer to Parts I, II, and III respectively, and are pecked where they project into another Part.

The first residuals of (5), those calculated by the equations (6), (7), (8), and their second differences are given in Table 13. The probable errors of a single residual, r_I, r_{II}, or r_{III}, based upon these calculations are.

in Part I $\varepsilon_I = \pm\ 5'.06$
" " II $\varepsilon_{II} = \pm\ 6'.87$
" " III $\varepsilon_{III} = \pm 19'.83$.

The lines of equal values of Declination which are combinations of the local characteristics with the general, are drawn on Map VII by the empirical expressions, which are the sum of the expressions of the first residuals and those of the general. In this Map, the lines in the boundary regions of the 3 Parts are connected by smooth curves.

For navigational purposes, we have connected these isogonic lines with those of the regions to the south and west of our present region. The isogonic lines for 1923.0 for the regions out of our own were computed from the British Admirality Magnetic Chart of 1924. We have also taken the Declination of the Siberian coast of Okhotsk Sea into process. The Declination of the Siberian coast is reduced, from the observed values of 30 stations along the coast, obtained from the Russian Admirality charts, into 1923.0 by our empirical formula of Secular Variation. These reduced values are given in Table 16. In Map VII, the isogonic lines of our region are extended in smooth curves to effect connections with the above data in the other regions.

Dip.

(1) Secular Acceleration $\left(\left[\frac{d^2\theta}{dt^2}\right]_{a\ \mathrm{year}}\right)$.

The values of the observations in Japan repeated four times in the

interval between 1887 and 1923 are given in Table 6 and plotted in Fig. 35.

Secular Acceleration after 1896 appears to have been very small.

(2) Secular Variation $\left(\left[\frac{d\theta}{dt}\right]_{a\ year}\right)$.

The stations observed twice in the interval between 1912 and 1923 are 83 in number and the values of the Mean Secular Variation of these stations are given in Table 8. The positions of all the stations and the values of their Secular Variation are given in Map VIII.

The Map indicates that the Secular Variation of Dip presents a systematic distribution, but the value is too small to be taken in consideration.

(3) Dip for the epoch 1923.0 (θ).

Observations of Dip in the region extending from 55°N to the equator and from 115°E to 175°E are accounted for by 232 stations, mostly observed at the epoch near 1923.0. As the Secular Variation is small and irregular, we have not reduced them to the epoch 1923.0. The resultant formula, which was computed from the observed values, may be considered to express the Dip for the epoch 1923.0.

(a) *General features.*

The empirical equation of Dip was calculated as a quadratic function of latitude and longitude by the method of least squares, each station having the same weight.

The result is;

$$\theta_{1923} = 48°15'.03 + 1°28'.5304\cdot\Delta\varphi - 8'.9891\cdot\Delta\lambda - 0'.581826.\Delta\varphi^2$$
$$-0'.510984\cdot\Delta\varphi\cdot\Delta\lambda + 0'.224952\cdot\Delta\lambda^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (9)$$

Where φ and λ represent the north latitude and the east longitude, and $\Delta\varphi=\varphi-35°$ and $\Delta\lambda=\lambda-135°$ expressed in degrees.

The positions of all the stations, used in this calculation, are shown in Map IX. The isoclinic lines expressed by the above formula are shown in Map IX.

The values of Dip, observed and calculated by the empirical expres-

sion (9), and their residuals are given in Table 12. The probable error of a single observation of Dip, based upon these calculation, is $\varepsilon = \pm 54'.72$.

(b) *Local characteristics.*

To find the local characteristics, we divided the whole region into two parts in the same way as in the case of Secular Variation of Declination.

Part I includes west of 150°E longitude.

" II " east " 140°E "

The empirical equations of the characteristics in each Part were computed by the method of least squares from the residuals of (9).
The numbers of the stations adopted in the computation, are in Part I 191, and in Part II 103.

The results of computation are;

$$\text{in Part I} \quad r_I = 35'.43 - 10'.7736 \cdot \Delta\varphi + 1'.6601 \cdot \Delta\lambda - 0'.301770 \cdot \Delta\varphi^2 + 0'.140226 \cdot \Delta\varphi \cdot \Delta\lambda - 0'.198222 \cdot \Delta\lambda^2 \quad \ldots\ldots \quad (10)$$

$$\text{" " II} \quad r_{II} = -11'.48 - 7'.5999 \cdot \Delta\varphi + 6'.0876\, \Delta\lambda - 0'.339990 \cdot \Delta\varphi^2 - 0'.020286 \cdot \Delta\varphi \cdot \Delta\lambda - 0'.127164 \cdot \Delta\lambda^2 \quad \ldots\ldots \quad (11)$$

The lines of equal local characteristics are drawn in Map X by these expressions, and the red and black lines are those for Parts I and II.

The values of first residual of (9), those calculated by the empirical equations (10) & (11) and their second difference, are given in Table 14. The probable errors of a single first residual, r_I or r_{II}, based upon these calculations are;

in Part I $\varepsilon_I = \pm\ 11'.33$

" " II $\varepsilon_{II} = \pm\ 25'.54$.

The lines of equal values of Dip which are combinations of the local characteristics with the general, are drawn in Map XI from the empirical expressions which are the sum of the expressions of the first residual and those of the general. The lines on the boundaries of two parts are connected by smooth curves.

Horizontal Intensity.

(1) Secular Acceleration $\left(\left[\frac{d^2H}{dt^2}\right]_{a\ year}\right)$.

The values of the observations repeated four times in Japan in the interval between 1887 and 1923 are given in Table 6 and plotted in Fig. 36. A remarkable amount of Secular Acceleration is observable in this figure.

(2) Secular Variation $\left(\left[\frac{dH}{dt}\right]_{a\ year}\right)$.

At 83 stations in Japan observations were repeated twice in the interval between 1912 and 1923 and the values of the Mean Secular Variation of these stations are given in Table 8 and their positions are shown in Map XII.

The empirical equation of the Mean Secular Variation was computed by the method of least squares from the data of 83 stations, each station having the same weight.

The result of computation is;

$$\left(\frac{dH}{dt}\right)_{1915}=1^{\gamma}.0-0^{\gamma}.778\cdot\Delta\varphi+0^{\gamma}.058\cdot\Delta\lambda+0^{\gamma}.00479\cdot\Delta\varphi^2$$
$$+0^{\gamma}.00102\cdot\Delta\varphi\cdot\Delta\lambda+0^{\gamma}.00580.\Delta\lambda^2 \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (12)$$

Where φ and λ are the north latitude and the east longitude, and $\Delta\varphi=\varphi-35°$ and $\Delta\lambda=\lambda-135°$ expressed in degrees.

The lines of equal Mean Secular Variation are drawn in Map XII by this expression.

The values of Secular Variation, observed and calculated by this expression, and their residuals are given in Table 9. The probable error of a single observation of Secular Variation, based upon these computations, is $\varepsilon=\pm 2^{\gamma}.091$.

The above empirical equation and the lines of equal values in Map XII, obtained by the Mean Secular Variation of the two surveys, are considered inaccurate owing to the fact the annual means at the magnetic observatories in and around the Pacific Ocean are generally very irregular.[1]

---

(1) *See page 53.*

(3) Horizontal Intensity for the epoch 1923.0 (H).

We have 164 stations where Horizontal Intensity was surveyed 1922—1923. As the Secular Variation is inaccurate, we have not reduced the observed values to the same epoch 1923.0. But the resultant formula which was computed from the observed values, may be considered to express fairly correctly the Horizontal Instensity for the epoch of 1923.0, because the observations made in the short interval of about a year.

(a) *General features.*

The empirical equation of Horizontal Intensity was calculated as a quadratic function of latitude and longitude by the method of least squares, each station having the same weight.

The result is;

$$H_{1923}=30445^{\gamma}.2-391^{\gamma}.509\cdot\Delta\varphi-61^{\gamma}.569\cdot\Delta\lambda-4^{\gamma}.85410\cdot\Delta\varphi^2$$
$$+4^{\gamma}.53205\cdot\Delta\varphi.\Delta\lambda+1^{\gamma}.75500\cdot\Delta\lambda^2 \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (13)$$

Where φ and λ represent the north latitude and the east longitude, and $\Delta\varphi=\varphi-35°$ and $\Delta\lambda=\lambda-135°$ expressed in degrees.

The positions of all the stations. used in this computation, are shown in Map XIII.

The lines of equal values are drawn in Map XIII by the above expression.

The values of Horizontal Intensity, observed and calculated by the expression (13) and their residuals are given in Table 12. The probable error of a single observation of Horizontal Intensity, based upon this computation, is $\varepsilon=\pm 214^{\gamma}.45$.

(b) *Local characteristics.*

To get the local characteristics, we divided the whole region into two parts as shown in Map XIV in the same way as in the case of Secular Variation of Declination.

Part I includes Japan and China.

„ II „ the southern parts of Japan and Marshall, Caroline, and Mariana Islands.

In Map XIV, the Parts I and II are enclosed by fine red and black lines.

The empirical equations of the local characteristics in each Part were computed by the method of least squares from the residuals of (13). In this calculation the residuals of 8 stations which are marked † in Table 12, were excluded, because they are considered to be abnormal. The numbers of stations adopted in this computation, are in Part I 140 and in Part II 29.

The results of computation are;

in Part I $r_I = 178^{\gamma}.1 + 6^{\gamma}.851 \cdot \Delta\varphi - 17^{\gamma}.651 \cdot \Delta\lambda - 3^{\gamma}.58148 \cdot \Delta\varphi^2$
$+ 5^{\gamma}.31987 \cdot \Delta\varphi . \Delta\lambda - 2^{\gamma}.82382 \cdot \Delta\lambda^2$ . . . . (14)

„ „ II $r_{II} = 811^{\gamma}.2 + 140^{\gamma}.217 \cdot \Delta\varphi - 121^{\gamma}.136 \cdot \Delta\lambda + 3^{\gamma}.55939 \cdot \Delta\varphi^2$
$- 7^{\gamma}.01687 \cdot \Delta\varphi \cdot \Delta\lambda - 1^{\gamma}.67129 \cdot \Delta\lambda^2$ . . . . (15)

The lines of equal local characteristics are drawn in Map XIV by these expressions. The red and the black lines are those of Parts I and II respectively, and such lines of each Part extending to other regions are shown by dotted lines.

The values of residuals of (13) and calculated by the empirical equations (14) & (15), and their differences are given in Table 15. The probable errors of a single residual, r_I or r_{II}, based upon these calculations are;

in Part I $\varepsilon_I = \pm\ 85^{\gamma}.86$
„ „ II $\varepsilon_{II} = \pm 154^{\gamma}.26$.

The lines of equal values of Horizontal Intensity which are the combinations of the local characteristics with the general, are drawn in Map XV by the empirical expressions which are the sum of the expressions of the first residual and those of the general. In Map XV, the lines on the boundaries of two parts are connected by smooth curves, and the lines of the regions extending beyond two parts are shown by the dotted lines.

The Components of Magnentic Force in North, West, and Upward Directions; (X), (Y), (Z).

The three components X, Y, Z of the magnetic force in north, west, and upward directions, are computed from the three observed elements,

Declination (δ), Dip (θ), and Horizontal Intensity (H), by the following formulas;

$$X = H \cdot \cos\delta, \qquad Y = H \cdot \sin\delta, \qquad Z = H \cdot \tan\theta.$$

and the values of the three components X, Y, Z at each station in this survey for 1922–1923, are given in Table 1 and 2.

The Iso-dynamic lines of X, Y, Z are given in Map XVI, XVII, and XVIII. The values of X, Y, Z at the intersections of entire degrees of latitude and longitude were computed from δ, θ, H, calculated by the empirical expressions. Then the Iso-dynamic lines were drawn by the usual method of interpolation.

TABLES.

Remarks on the Tables.

(1) The values of south latitude and west longitude have negative signs attached to them.

(2) The values of easterly Declination and southerly Dip have negative signs attached to them.

(3) * and † indicate the values of abnormals.

TABLE I.

RESULTS OF MAGNETIC OBSERVATIONS BY THE JAPANESE HYDROGRAPHIC DEPARTMENT FOR 1922–1923.

Remarks;

(1) To indicate the spots of observation in their relation to the former survey of 1913, the following abbreviations are used in the list.

Abbreviations.

A	denotes	that	the position of observation and its surroundings are the same as those of 1913 survey.
B	,,	,,	the position of observation is the same as that of 1913 survey, but its surroundings were changed.
C	,,	,,	the position was slightly changed, but the surroundings remained the same.
D	,,	,,	the position and the surroundings were both changed slightly.
N	,,		the new spot of observation.

(2) In the column for observers,

1 denotes 1st. Surveying Party (Tosihiko Ogawa and Bunpei Kobayasi),

2 ,, 2nd. ,, ,, (Yukiyosi Ôtani and Kingo Nagoya),

3 ,, 3rd. ,, ,, (Kôzi Kobayasi and Gorô Oka).

(3) The three elements of rectangular co-ordinates X, Y, and Z are the magnetic forces in north, west, and upward directions, and computed from observed values of δ, θ, & H.

Station No.	Station Name	Spot of Observation: Latitude	Spot of Observation: Longitude	Relation to former survey	Date	Three Elements of Terrestrial Magnetism: Declination	Dip	Horizontal Intensity	Three Elements of Rectangular Co-ordinates: X	Y	Z	Observers
	KARAHUTO 樺太											
		° ′	° ′		1922	° ′	° ′	γ	γ	γ	γ	
1	敷香 Sikuka	49 13.6	143 07.1	A	14 July	8 46.7	62 53.6	23867	23585	3656	46630	3
2	鵜城 Usyoro	48 50.8	141 56.7	”	24 June	8 54.8	62 35.2	24111	23818	3748	46491	”
3	東白浦 Higasi-Siraoro	47 51.3	142 31.4	N	7 July	8 18.0	61 37.1	24571	24312	3561	45477	”
4	眞岡 Maoka	47 02.8	142 03.0	A	18 June	8 43.0	60 50.4	25096	24804	3818	44981	”
5	豊原 Toyohara. ...	46 57.6	142 43.0	”	3 July	8 37.1	60 42.4	25162	24876	3786	44860	”
6	大泊 Ôtomari... ...	46 38.8	142 46.3	N	30 ”	8 17.1	60 23.8	25304	25038	3657	44538	”
	HOKKAIDÔ 北海道											
		° ′	° ′		1922	° ′	° ′	γ	γ	γ	γ	
7	稚内 Wakkanai ...	45 25.5	141 40.4	C	13 Sept.	8 20.5	59 18.9	25961	25685	3772	43750	3
8	紋別 Monbetu.. ...	44 21.2	143 21.5	A	9 ”	7 31.8	57 58.9	26366	26138	3463	42167	”
9	留萌 Rumoi	43 56.9	141 37.9	C	12 Aug.	7 41.1	57 56.8	26598	26358	3566	42478	”
10	旭川 Asahikawa ...	43 45.0	142 22.7	”	15 ”	7 48.1	57 37.1	26540	26293	3612	41853	”
11	標津 Sibetu	43 39.8	145 07.0	A	29 ”	6 51.4	57 23.2	26318	26129	3150	41131	”
12	札幌 Sapporo... ...	43 04.2	141 20.8	”	27 ”	7 29.6	57 03.9	26773	26543	3499	41331	”
13	白糠 Siranuka	42 56.7	144 04.4	”	2 Sept.	6 30.2	56 38.5	26864	26690	3051	40811	”
14	池田 Ikeda	42 55.6	143 25.5	C	5 ”	6 47.5	56 37.1	26859	26670	3184	40762	”
15	佐留太 Saruhuto ...	42 31.0	142 02.0	”	9 Aug.	7 17.0	56 36.5	26995	26776	3431	40963	”
16	瀬棚 Setana	42 27.2	139 51.0	A	13 June	7 29.6	56 19.8	27436	27200	3593	41188	”
17	茂寄 Moyori	42 16.9	143 18.9	”	19 Aug.	6 45.0	55 46.9	27256	27066	3214	40079	”
18	森 Mori	42 06.4	140 34.0	”	9 June	7 17.0	56 06.6	27412	27188	3496	40829	”
	HONSYÛ 本洲											
		° ′	° ′		1922	° ′	° ′	γ	γ	γ	γ	
19	野邊地 Nohezi	40 52.2	141 06.6	A	27 July	7 01.1	54 37.3	27874	27601	3405	39164	1
20	鰺ヶ澤 Azigasawa ...	40 46.4	140 12.1	”	1 Aug.	6 46.1	54 47.5	27955	27759	3303	39617	”
21	大館 Ôdate	40 16.6	140 32.4	”	4 ”	6 45.0	54 04.1	28093	27897	3309	38763	”
22	久慈 Kuzi	40 11.4	141 47.0	”	24 July	6 15.0	54 03.9	28234	28065	3084	38958	”
23	秋田 Akita	39 42.5	140 06.8	”	6 Aug.	6 31.4	53 33.0	28520	28335	3247	38613	”
24	横手 Yokote	39 20.0	140 34.1	”	24 ”	6 24.9	52 58.6	28749	28568	3219	38117	”
25	水澤 Mizusawa ...	39 08.5	141 08.0	”	21 July	6 18.3	52 39.3	28604	28430	3150	37490	”
26	米ヶ崎 Yonegasaki ...	39 00.4	141 39.0	C	17 ”	6 11.8	52 46.9	28362	28195	3071	37341	”
27	酒田 Sakata	38 55.2	139 50.1	B	27 Aug.	6 24.7	52 42.9	28816	28635	3225	37850	”
28	山形 Yamagata ...	38 15.8	140 20.4	C	30 ”	6 01.5	51 50.7	29053	28892	3056	36975	”
29	仙臺 Sendai	38 15.0	140 52.4	D	12 July	6 07.0	51 51.2	28781	28616	3076	36644	”

HONSYÛ 本 洲

Station No.	Station Name	Spot of Observation Latitude ° ′	Spot of Observation Longitude ° ′	Relation to former survey	Date	Three Elements of Terrestrial Magnetism Declination ° ′	Dip ° ′	Horizontal Intensity γ	Three Elements of Rectangular Co-ordinates X γ	Y γ	Z γ	Observers
30	新潟 Niigata	37 55.4	139 01.9	A	1922 4 Sept.	6 18.2	51 43.5	29137	28960	3205	36925	1
31	若松 Wakamatu ...	37 29.4	139 57.4	,,	1 ,,	5 52.0	51 10.5	29153	29000	2985	36227	,,
32	輪島 Wazima... ...	37 23.8	136 53.5	C	13 ,,	6 10.5	51 15.6	29587	29415	3189	36874	,,
33	十日町 Tôkamati ...	37 08.7	138 45.2	A	7 ,,	6 00.9	50 58.7	29504	29341	3098	36404	,,
34	糸魚川 Itoigawa.. ...	37 02.8	137 52.0	,,	10 ,,	6 06.7	50 52.9	29490	29322	3146	36262	,,
35	黒磯 Kuroiso	36 58.1	140 03.8	,,	9 June	6 06.1	50 21.9	* 29437	* 29270	* 3135	* 35533	,,
36	上田 Ueda	36 54.5	140 48.6	,,	1923 28 Jan.	5 36.3	50 15.5	29399	29259	2870	35359	3
37	水戸 Mito	36 22.6	140 29.2	,,	30 ,,	5 30.5	49 38.5	29605	29468	2840	34837	,,
38	松井田 Matuida... ...	36 18.8	138 47.9	C	24 ,,	5 48.9	49 39.0	29844	29691	3022	35129	,,
39	鹽屋 Sioya	36 17.8	136 14.5	A	1922 16 Sept.	6 07.0	50 19.7	29940	29769	3197	36104	1
40	銚子 Tyôsi	35 43.5	140 50.8	,,	1923 2 Feb.	5 12.3	48 26.4	30065	29941	2727	33913	3
41	八王子 Hatiôzi	35 39.5	139 21.6	,,	19 Jan.	5 28.3	48 41.9	30001	29864	2860	34147	,,
42	宮津 Miyazu	35 32.1	135 11.7	C	1922 13 Nov.	5 44.9	49 19.3	30438	30285	3051	35415	,,
43	飯田 Iida...	35 31.2	137 50.7	A	30 Oct.	5 31.6	48 51.5	30123	29983	2905	34476	,,
44	小濱 Obama	35 30.4	135 44.4	,,	6 Nov.	5 44.9	49 12.5	30435	30282	3051	35270	,,
45	鳥取 Tottori	35 30.4	134 14.6	,,	16 ,,	5 54.8	49 35.1	30499	30336	3145	35817	,,
46	長濱 Nagahama ...	35 22.5	136 15.4	,,	3 ,,	5 40.0	49 01.0	30370	30221	3003	34957	,,
47	今市 Imaiti	35 21.3	132 45.4	,,	22 ,,	5 41.4	49 51.2	30511	30360	3027	36173	,,
48	黒坂 Kurosaka ...	35 12.2	133 23.2	,,	20 ,,	5 41.8	49 18.9	30694	30542	3049	35702	,,
49	温泉津 Yunotu	35 05.7	132 20.7	C	24 ,,	5 14.2	49 53.9	30447	30320	2781	36155	,,
50	上賀茂 Kamikamo ...	35 03.3	135 46.2	,,	10 ,,	5 32.8	48 40.9	30573	30430	2958	34778	,,
51	富田 Tomida	35 00.0	136 39.2	A	1923 10 Jan.	5 33.0	48 28.5	30452	30309	2944	34390	,,
52	掛川 Kakegawa ...	34 46.4	138 01.1	,,	16 ,,	5 16.5	47 56.4	30426	30297	2796	33720	,,
53	豊橋 Toyohasi.. ...	34 45.5	137 23.7	,,	13 ,,	5 24.5	48 10.2	30432	30297	2868	34001	,,
54	岡山 Okayama ...	34 40.5	133 56.0	,,	1922 28 Nov.	5 30.5	48 25.5	30892	30749	2967	34823	,,
55	宮川 Miyagawa ...	34 30.8	136 40.5	,,	1923 7 Jan.	5 20.9	47 53.3	30625	30492	2854	33880	,,
56	廣島 Hirosima	34 22.8	132 27.2	,,	1922 1 Dec.	5 20.1	48 15.4	31162	31027	2899	34922	,,
57	洲本 Sumoto	34 20.5	134 53.2	,,	25 ,,	5 21.1	47 51.8	30915	30780	2884	34170	,,
58	山口 Yamaguti. ...	34 10.5	131 28.5	,,	1923 11 Feb.	5 15.7	48 10.0	31304	31172	2869	34971	2
59	南部 Minabe	33 45.7	135 19.2	,,	1922 29 Dec.	5 09.1	47 05.0	31030	30905	2786	33373	3
60	勝浦 Katuura... ...	33 37.7	135 56.8	,,	1923 3 Jan.	5 04.4	46 52.4	31017	30896	2743	33115	,,

SIKOKU 四 國

Station No.	Station Name	Spot of Observation: Latitude	Spot of Observation: Longitude	Relation to former survey	Date	Three Elements of Terrestrial Magnetism: Declination	Dip	Horizontal Intensity	Three Elements of Rectangular Co-ordinates: X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
61	Tokusima ...	34 04.0	134 34.4	A	1922 21 Dec.	5 15.9	47 30.1	31017	30886	2847	33851	3
62	Imaharu ...	34 03.8	133 00.5	„	4 „	5 19.1	47 48.3	31165	31031	2891	34376	„
63	Ôsato ...	33 36.0	134 22.2	„	17 „	5 08.4	46 59.8	31191	31065	2795	33444	„
64	Wakamiya ...	33 31.4	132 33.8	„	8 „	5 05.4	47 06.7	31372	31248	2784	33772	„
65	Susaki ...	33 23.1	133 17.1	„	12 „	5 04.4	46 54.3	31340	31217	2772	33497	„

KYÛSYÛ 九 州

		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
66	Izuhara ...	34 12.5	129 17.2	A	1922 10 Dec.	5 21.5	48 40.2	31373	31236	2931	35673	2
67	Nakatu ...	33 36.4	131 11.2	„	1923 8 Feb.	5 09.4	47 37.0	31473	31346	2827	34487	„
68	Karatu ...	33 27.4	129 57.5	„	1922 14 Dec.	5 01.3	47 33.0	31575	31454	2765	34518	„
69	Saheki ...	32 57.1	131 53.6	„	1923 6 Feb.	4 49.9	46 47.8	31570	31458	2657	33615	„
70	Miyazi ...	32 56.0	131 07.0	N	1922 24 Dec.	4 34.2	46 52.2	31624	31523	2520	33759	„
71	Simabara ...	32 47.2	130 22.0	A	21 „	4 45.4	46 34.8	31726	31617	2632	33526	„
72	Nagasaki ...	32 45.6	129 51.6	N	19 „	6 24.7*	49 14.3*	31246	31051*	3490*	36248*	„
73	Zaikôzi ...	32 24.6	131 37.8	A	1923 4 Feb.	4 43.0	46 01.0	31895	31787	2621	33048	„
74	Hitoyosi ...	32 13.3	130 45.6	„	1922 29 Dec.	4 36.5	45 45.1	32032	31928	2573	32884	„
75	Usibuka ...	32 11.6	130 01.2	„	27 „	4 31.2	46 49.6*	32134	32034	2532	34251*	„
76	Miyazaki ...	31 55.4	131 25.1	„	1923 2 Feb.	4 32.0	45 23.8	32122	32023	2538	32570	„
77	Nisi-Itiki ...	31 41.1	130 17.5	B	4 Jan.	3 59.2	45 10.8	32127	32049	2234	32330	„
78	Makurazaki ...	31 16.1	130 17.0	A	7 „	3 54.5	44 49.4	32232	32157	2197	32034	„
79	Nisi-no-Omote	30 44.3	130 59.1	„	10 „	4 08.6	43 42.7	32571	32486	2353	31138	„
80	Naze ...	28 22.4	129 29.9	„	19 „	3 24.3	40 29.4	33528	33469	1990	28626	„

TYÔSEN 朝 鮮

		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
81	Yûki ...	42 19.8	130 23.7	A	1922 22 Aug.	7 36.2	58 04.4					2
82	Zyôsin ...	40 40.1	129 11.5	N	18 „	7 03.7	56 41.0	28364	28148	3495	43152	„
83	Hokusei ...	40 13.9	128 19.3	B	11 „	6 47.8	56 10.8	28618	28416	3394	42722	„
84	Gisyû ...	40 12.4	124 28.7	A	25 July	6 09.6	56 55.4	28448	28283	3061	43686	„
85	Kisen ...	40 10.0	126 10.0	„	14 „	6 33.1	56 26.3	28649	28461	3278	43194	„
86	Kizyô ...	39 59.2	125 14.0	C	21 „	6 19.7	56 17.7	28762	28586	3179	43119	„
87	Eikô ...	39 32.6	127 14.2	D	30 „	6 28.5	55 37.7	28890	28705	3265	42237	„
88	Genzan ...	39 09.8	127 26.3	N	3 Aug.	6 28.5	55 01.8	29200	29014	3293	41748	„
89	Heizyô ...	39 00.3	125 41.8	A	8 July	6 00.9	55 07.6	29349	29187	3083	42121	„

TYÔSEN 朝鮮

Station No.	Station Name	Spot of Observation: Latitude	Spot of Observation: Longitude	Relation to former survey	Date	Three Elements of Terrestrial Magnetism: Declination	Dip	Horizontal Intensity	Three Elements of Rectangular Co-ordinates: X	Y	Z	Observers
		° ′	° ′		1922	° ′	° ′	γ	γ	γ	γ	
90	長箭 Tyôzen	38 44.6	128 10.8	N	29 Aug.	5 26.1	54 27.0	29347	29215	2786	41067	2
91	Zuikô	38 26.8	126 08.5	B	25 June	5 52.2	54 18.6	29630	29474	3039	41254	„
92	Mukinpo.. ...	38 11.0	124 46.1	A	2 July	5 38.2	54 15.3	29736	29592	2929	41318	„
93	注文津 Tyûmonzin ...	37 53.9	128 49.7	„	3 Sept.	6 10.2	53 15.4	29755	29582	3207	39850	„
94	春川 Syunsen	37 52.4	127 40.9	„	22 June	6 05.2	53 30.2	29842	29673	3173	40334	„
95	仁川 Zinsen	37 29.9	126 37.6	„	18 „	5 39.4	53 08.8	30036	29889	2966	40070	„
96	竹邊 Tikuhen... ...	37 03.9	129 22.5	N	11 Sept.	5 37.2	52 12.6	30078	29933	2951	38790	„
97	忠州 Tyûsyû	36 57.7	127 54.9	C	14 June	5 33.7	52 03.2	30161	30018	2930	38678	„
98	Gôsen	36 26.1	126 31.1	A	8 Nov.	5 35.4	51 49.8	30540	30391	2979	38142	„
99	Kôkan	36 11.0	127 58.9	„	23 Aug.	5 29.4	51 20.3	30573	30432	2930	38213	„
100	浦項 Hokô	36 02.3	129 22.1	N	15 Sept.	5 40.9	51 01.3	30482	30332	3021	37672	„
101	大邱 Taikyû	35 51.2	128 35.8	C	1 Nov.	5 37.9	50 42.0	30727	30578	3018	37541	„
102	全州 Zensyû	35 49.7	127 07.8	N	12 „	5 21.3	50 59.1	30770	30636	2873	37978	„
103	晋州 Sinsyû	35 12.0	128 06.6	A	1 Dec.	5 06.3	50 04.1	30994	30871	2760	37025	„
104	光州 Kôsyû	35 08.8	126 54.4	„	15 Nov.	5 10.7	50 10.8	31008	30881	2802	37193	„
105	釜山 Huzan	35 05.3	129 02.0	N	20 Sept.	5 21.1	49 41.0	31185	31049	2913	36751	„
106	木浦 Moppo	34 46.9	126 23.5	A	18 Nov.	4 50.2	49 42.6	31324	31212	2644	36949	„
107	Kôyô	34 35.9	127 16.7	„	25 „	4 54.7	49 51.0	31019	30905	2657	36771	„
108	Hônan	34 31.6	127 15.0	„	28 „	4 29.9	49 21.3	31272	31176	2455	36426	„

KWANG-TUNG AND TSINGTAU PENINSULA

Station No.	Station Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′		1922	° ′	° ′	γ	γ	γ	γ	
109	普蘭店 Pu-lan-tien ...	39 24.0	121 57.1	N	23 Nov.	5 25.2	56 15.2	28900	28701	2731	43257	1
110	周水子 Chou-shui-tzu	38 57.2	121 33.0	„	28 „	5 14.9	55 40.7	29294	29171	2681	42908	„
503	青島 Tsingtau	36 04.9	120 18.8		16 „	4 16.3	52 09.8	30856	30770	2301	39747	„

RYUKYÛ 琉球

Station No.	Station Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′		1923	° ′	° ′	γ	γ	γ	γ	
111	名護 Nago.	26 35.7	127 59.0	A	26 Jan.	2 45.2	37 45.3	34353	34313	1649	26604	2
112	那覇 Naha.	26 12.7	127 39.9	N	25 „	2 27.5	37 10.9	34563	34531	1482	26217	„
113	宮古 Miyako	24 48.5	125 18.1	A	10 Feb.	2 03.8	35 00.4	35253	35230	1268	24691	1
114	石垣 Isigaki	24 20.0	124 09.5	D	16 „	1 55.2	34 11.2	35594	35574	1191	24178	„

TAIWAN 臺灣

Station No.	Station Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′		1922	° ′	° ′	γ	γ *	γ *	γ *	
115	淡水 Tansui	25 10.5	121 25.7	A	13 Dec.	1 57.6	35 55.5	35349	35328	1215	25618	1
116	臺北 Taihoku... ...	25 02.3	121 30.8	N	10 „	1 59.5	35 25.5	35806	35784	1249	25470	„

TAIWAN 臺 灣

Station No.	Station Name	Spot of Observation: Latitude	Spot of Observation: Longitude	Relation to former survey	Date	Three Elements of Terrestrial Magnetism: Declination	Dip	Horizontal Intensity	Three Elements of Rectangular Co-ordinates: X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
117	鹿港 Rokkō	24 02.8	120 26.2	A	1922 17 Dec.	1 20.5	33 35.9	36012	36002	847	23916	I
118	花蓮港 Kwarenkō ...	23 58.6	121 36.5	„	1923 9 Jan.	1 22.1	33 41.0	35979	35969	859	23980	„
119	澎湖島 Hōkotō ...	23 34.2	119 33.8	„	1922 26 Dec.	0 53.9	32 45.6	36370	36366	573	23400	„
120	臺南 Tainan... ...	23 00.0	120 12.2	D	20 „	1 10.2	31 52.7	36531	36523	749	22719	„
121	卑南 Pinan	22 45.1	121 09.3	C	1923 5 Jan.	1 06.4	31 29.2	36488	36481	705	22348	„
122	大板埒 Taihanroku ..	21 57.5	120 46.2	A	14 „	0 57.3	29 59.3	36754	36749	611	21210	„

OGASAWARA 小 笠 原

No.	Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
123	奥村 Okumura ...	27 05.8	142 11.9	D	1922 22 June	2 39.8	36 54.1	32025	31990	1496	24046	I
124	大村 Omura... ...	27 05.3	142 11.1	A	19 „	2 39.9	37 28.2	31944	31909	1494	24470	„
125	扇浦 Ogiura... ...	27 04.3	142 11.3	D	24 „	3 04.2	37 27.7	32220	32173	1734	24689	„
126	東港 Higasiminato	26 41.4	142 08.4	„	30 „	2 37.4	37 06.8	32165	32131	1480	24338	„
127	北村 Kitamura ...	26 41.3	142 08.6	„	29 „	2 35.4	36 53.7	31818	31785	1445	23885	„
128	沖村 Okimura ...	26 38.1	142 09.2	A	2 July	2 16.9	36 54.6	32361	32335	1298	24302	„
129	南崎 Minamizaki ..	26 37.0	142 10.2	„	3 „	2 21.8	37 12.9	32190	32162	1338	24438	„

MARIANA ISLANDS

No.	Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
130	Pagan	18 07.6	145 46.0	identical to 1916	1923 26 Apr.	−0 41.5	22 31.9	33372	33370	−407	13845	I
131	Saipan... ...	15 13.1	145 43.3	identical to 1915	1 May	−1 49.5	17 28.3	34385	34368	−1097	10823	„
132	„	15 09.3	145 44.9	new station	3 „	−1 35.5	17 25.9	34373	34360	−957	10793	„

WEST CAROLINE ISLANDS

No.	Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
133	Yap	9 31.4	138 08.5	identical to 1917	1923 26 May	−1 53.9	5 45.0	36740	36720	−1216	3700	I
134	Palau	7 20.5	134 28.3	new station	13 „	−2 10.1	1 30.1	37448	37421	−1418	982	„
135	„	7 20.2	134 30.1	new station	16 „	−2 00.0	1 27.8	36835	36813	−1287	941	„
136	„	7 19.9	134 27.5	identical to 1918	19 „	−2 19.1	1 20.9	37361	37330	−1520	879	„

EAST CAROLINE ISLANDS

No.	Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
137	Olol	8 35.0	149 39.3	identical to 1916	1923 5 June	−3 57.7	5 36.3	35234	35149	−2439	3458	I
138	Truk	7 22.5	151 53.7	new station	12 „	−5 32.8	0 47.6	33843	33685	−3271	469	„
139	Wolea	7 22.3	143 54.2	identical to 1915	31 May	−3 01.2	2 02.6	36191	36141	−1907	1291	„
140	Truk	7 21.4	151 53.3	identical to 1917	9 June	−3 32.7	2 05.1	35668	35599	−2210	1299	„

EAST CAROLINE ISLANDS

Station No.	Station Name	Spot of Observation: Latitude	Spot of Observation: Longitude	Relation to former survey	Date	Three Elements of Terrestrial Magnetism: Declination	Dip	Horizontal Intensity	Three Elements of Rectangular Co-ordinates: X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
141	Lossop	6 53.6	152 44.0	new station	1923 19 June	−4 35.5	1 39.2	34995	34883	−2801	1010	1
142	Ponape... ...	6 47.9	158 09.4	identical to 1918	26 " "	−5 58.6	2 45.2	34959	34769	−3638	1681	"
143	Kusaie	5 20.2	163 01.0	identical to 1920	3 July	−6 23.9	2 31.9	34207	33994	−3811	1557	"
144	Mortlock ...	5 20.1	153 44.0	identical to 1916	22 June	−5 08.4	−0 40.0	35500	35357	−3185	413	"

MARSHALL ISLANDS

Station No.	Station Name	Latitude	Longitude	Relation to former survey	Date	Declination	Dip	Horizontal Intensity	X	Y	Z	Observers
		° ′	° ′			° ′	° ′	γ	γ	γ	γ	
145	Brown	11 20.6	162 20.5	identical to 1917	1923 18 July	−6 19.3	12 08.8	33154	32952	−3651	7136	1
146	Rongelab ...	11 08.9	166 53.6	identical to 1917	14 " "	−7 23.5	13 31.0	32333	32065	−4155	7772	"
147	Jaluit	5 54.8	169 38.9	identical to 1915	9 " "	−8 03.8	4 43.7	34092	33857	−4792	2828	"

TABLE 2.

RESULTS OF MAGNETIC OBSERVATIONS
BY THE CHINESE GOVERNMENT FOR 1922–1923.

Remark:

(1) The blanks in the column headed in "Relation to Former Surveys" indicate the new spots of observations.

CHINA

Station		Spot of Observation				Relation to former surveys	Date	Three Elements of Terrestrial Magnetism					Three Elements of Rectangular Co-ordinates		
No.	Name	Latitude		Longitude				Declination		Dip		Horizontal Intensity	X	Y	Z
		°	′	°	′			°	′	°	′	γ	γ	γ	γ
201	Newchwang ...	40	40.4	122	16.2	identical with 1907 1916	1922 4 Oct.	5	44.4	57	49.7	28180	28039	2818	44798
202	Shanhaikwan	39	58.3	119	45.		„ 26 Sept.	5	31.6	57	04.3	28842	28708	2778	44535
203	Tientsin... ...	39	05.8	117	10.6	identical with 1916	„ 17 „	4	23.5	56	25.1	29211	29125	2237	43997
204	Chefoo	37	32.1	121	24.9		„ 7 „	5	00.3	53	50.2	30146	30031	2630	41245
205	Tsinan	36	39.2	117	00.2	near to 1915	„ 7 Dec.	3	59.2	53	04.2	30803	30728	2142	40981
206	Yangchow Residence	32	23.3	119	26.6		„ 12 May.	3	22.1	47	15.6	32774	32717	1926	35467
207	„ Hospital	32	22.5	119	25.6		„ 14 „	3	21.8	47	14.2	32812	32755	1925	35479
208	Chinkiang Residence	32	13.1	119	25.1		„ 6 „	3	29.1	46	54.7	32970	32909	2004	35247
209	„ Vict. Park	32	12.	119	24.9		„ 9 „	3	27.6	46	58.9	33020	32960	1993	35387
210	Nanking... ...	32	02.6	118	46.2		„ 2 „	2	38.2	46	46.4	32941	32906	1515	35046
211	Woosung.. ...	31	23.3	121	30.1		„ 23 „	3	21.3	45	34.4	33236	33179	1945	33908
212	Hangchow ...	30	19.4	120	08.1	identical with 1906 1917	1923 1 Feb.	3	02.6	44	01.7	33746	33698	1792	32620
213	Putu	29	59.9	122	22.7		„ 8 „	3	31.6	43	52.2	33907	33843	2086	32595
214	Ningpo	29	53.8	121	34.2	near to 1917	1922 29 May.	3	13.0	43	23.4	33723	33670	1892	31879
215	Wenchow ...	28	01.6	120	39.1	very close to 1917	„ 25 Nov.	2	22.6	40	47.1	34354	34324	1425	29638
216	Foochow ...	26	02.6	119	18.8	identical with 1917	„ 29 June	1	53.8	37	29.6	35518	35499	1176	27247
217	Amoy	24	26.6	118	04.0	identical with 1906 1917	„ 14 „	1	13.8	34	55.6	36134	36126	776	25232
218	Swatow	23	21.5	116	40.4	identical with 1906 1917	„ 22 „	0	55.0	32	40.0	36815	36810	589	23605

TABLE 3.

RESULTS OF LAND AND OCEAN MAGNETIC OBSERVATIONS BY THE CARNEGIE INSTITUTION OF WASHINGTON FOR 1912-1917.

CHINA

Station No.	Station Name	Spot or Mean Spot of Observations: Latitude	Spot or Mean Spot of Observations: Longitude	Date	Three Elements of Terrestrial Magnetism: Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
301	Mean of 3 Stations	49 12.0	119 43.4	1916.73	6 48.0	67 01.0	
302	" 6 "	46 14.8	125 47.2	1916.72	7 43.1	62 59.4	
303	" 23 "	41 15.6	123 08.6	1916.61	6 01.5	58 06.0	
304	Peking	39 56.6	116 25.0	1915.64	3 55.3	57 18.6*	28874
305	Mean of 22 Stations	39 48.5	117 11.3	1915.86	4 00.2	57 09.2	
306	Liangchowfu	37 56.8	102 45.	1916.07	−0 07.4	55 30.6	30007
307	Sianfu	34 16.3	108 57.	1915.97	1 12.5	50 33.5	32273
308	Suchow. An	33 39.1	116 58.	1915.61	2 57.3	49 00.7	
309	Wuhu	31 21.1	118 20.	1911.67	2 49.6	45 43.6	33858
310	Soochow	31 20.3	120 39.	1911.69	2 40.1	45 47.6	33314
311	Nanchang	28 41.7	115 51.	1911.61	1 36.6	41 52.2	34854
312	Mean of 30 Stations	26 54.3	117 46.3	1917.78	1 41.8	38 49.0	
313	Shiuchow	24 47.6	113 22.	1915.23	0 46.7	35 10.5	36542
314	Mengtsz	23 28.3	103 25.	1917.36	0 02.4	32 33.0	37612
315	Canton	23 06.1	113 18.	1911.65	0 11.4	32 09.8	37188

PACIFIC ISLANDS

No.	Name	Latitude	Longitude	Date	Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
316	Guam, Orotè Point	13 37.	144 37.	1916.57	−1 56.8	14 05.4	
317	" Cabras Island	13 28.	144 40.	1916.59	−2 00.0	14 03.6	35042
318	" Sumay	13 26.2	144 39.	1916.56	−1 59.1	14 02.9	
319	Maraki Island	2 00.2	173 16.	1915.50	−8 54.1	−2 11.6	
320	Apaiang "	1 51.0	173 00.0	1915.50	−8 46.4	−1 49.9	
321	Tarawa "	1 21.2	172 55.	1915.50	−8 55.0	−3 13.3	
322	Papeete	−17 31.8	210 27.	1916.44	−8 24.5	−30 09.6	33428
323	Small Coral Island	−17 32.0	210 25.	1916.44	−10 09.5	−29 45.1	33750
324	Suva Vou, A	−18 07.1	178 25.	1912.45	−10 23.5	−38 28.0	34719
325	Suva. Dr. Klotz's St.	−18 08.8	178 26.	1915.35	−10 16.8	−38 20.4	34846

PACIFIC OCEAN, THE CARNEGIE'S CRUISE II.

No.	Name	Latitude	Longitude	Date	Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	
326	Mean of 5 Stations	0 33.0	130 45.4	1912.04	−2 46.2		
327	" 4 "	0 44.8	132 32.5	1912.05		−12 36.2	
328	" 3 "	2 11.6	137 04.6	1912.06	−3 08.6		
329	" 2 "	3 42.5	137 25.5	1912.06		−5 54.0	
330	" 6 "	6 55.9	136 15.0	1912.07	−2 23.3		

PACIFIC OCEAN, THE CARNEGIE'S CRUISE II.

Station		Mean Spot		Date	Three Elements of Terrestrial Magnetism		
No.		Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	
331	Mean of 3 Stations	9 21.4	134 32.3	1912.07		5 40.7	
332	" 5 "	13 57.2	129 48.6	1912.08	−0 48.0		
333	" 3 "	15 27.7	128 11.6	1912.08		17 52.7	
334	" 19 "	18 08.8	120 27.7	1912.18	−0 11.1		
335	" 16 "	20 01.9	121 28.2	1912.22		26 27.4	
336	" 3 "	25 56.3	130 02.6	1912.29	2 10.6		
337	" 4 "	26 25.3	131 47.0	1912.29		37 23.3	
338	" 3 "	30 38.3	138 18.4	1912.30	3 22.7		
339	" 6 "	30 51.4	144 26.2	1912.31		42 35.8	
340	" 3 "	30 55.3	145 22.3	1912.31	2 34.0		
341	" 3 "	31 01.0	152 34.0	1912.32	0 25.0		
342	" 4 "	30 30.0	159 48.2	1912.32	−2 11.0		
343	" 5 "	30 08.2	163 12.8	1912.32		41 29.6	
344	" 6 "	26 27.3	170 03.8	1912.33	−6 47.8		
345	" 2 "	24 39.0	171 16.0	1912.33		36 13.5	
346	" 2 "	18 57.0	173 10.0	1912.34		28 55.5	
347	" 3 "	18 09.0	173 19.4	1912.34	−8 30.0		
348	" 2 "	13 49.0	174 47.5	1912.35		21 35.5	
349	" 3 "	12 08.7	175 44.0	1912.35	−8 45.0		

PACIFIC OCEAN, THE CARNEGIE'S CRUISE IV.

		° ′	° ′		° ′	° ′	
350	Mean of 2 Stations	54 41.0	173 39.0	1915.63		65 30.0	
351	" 5 "	54 21.8	173 02.4	1915.63	−4 31.2		
352	" 4 "	50 03.5	168 41.3	1915.64		61 33.0	
353	" 6 "	48 33.8	167 36.0	1915.64	−1 48.0		
354	" 4 "	45 20.0	164 04.0	1915.65		57 09.0	
355	" 6 "	44 56.5	163 28.0	1915.65	−0 31.0		
356	" 3 "	38 44.0	164 16.0	1915.65		50 42.0	
357	" 7 "	37 45.9	164 38.3	1915.66	−2 24.0		
358	" 4 "	33 44.5	169 47.3	1915.66	−5 21.0		
359	" 4 "	32 31.3	170 04.0	1915.67		44 46.5	
360	" 11 "	28 32.3	170 16.3	1915.68	−6 33.8		
361	" 2 "	28 38.0	170 22.0	1915.67		40 27.1	

PACIFIC OCEAN, THE CARNEGIE'S CRUISE IV.

Station		Mean Spot		Date	Three Elements of Terrestrial Magnetism		
No.		Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	
362		25 50.0	168 43.0	1915.68		36 42.0	
363	Mean of 2 Stations	21 13.0	167 08.0	1915.68		30 42.0	
364	" 4 "	21 06.2	168 48.8	1915.69		30 30.0	
365	" 12 "	20 48.7	167 53.9	1915.69	−6 51.0		
366	" 2 "	19 17.5	166 38.5	1915.70		27 06.0	
367	" 3 "	15 22.0	165 09.4	1915.70		20 36.0	
368	" 10 "	14 45.1	165 32.4	1915.71	−6 52.8		
369	" 2 "	13 37.5	166 08.0	1915.71		18 09.0	
370	" 3 "	11 05.3	164 16.7	1915.72		12 16.0	
371	" 13 "	9 20.0	164 07.8	1915.72	−6 58.6		
372	" 2 "	8 25.5	163 36.0	1915.73		7 51.0	
373	" 2 "	6 00.5	164 27.0	1915.73		3 27.0	
374	" 3 "	3 56.3	163 55.3	1915.74		−0 38.0	
375	" 3 "	2 51.7	163 11.0	1915.74		−3 28.0	
376	" 15 "	3 09.1	162 36.2	1915.74	−7 10.0		
377	" 2 "	1 05.0	160 16.0	1915.75		−7 36.0	
378	" 5 "	16 04.8	173 12.8	1916.51	−8 32.4		
379	" 5 "	16 37.0	171 58.2	1916.51		24 51.6	
380	" 5 "	18 37.8	166 59.8	1916.51	−6 56.4		
381	" 5 "	19 53.8	161 07.4	1916.52		26 50.4	
382	" 8 "	20 00.9	160 20.5	1916.53	−4 39.0		
383	" 4 "	17 38.3	154 06.8	1916.53	−3 15.0		
384	" 5 "	15 53.8	150 21.6	1916.53		19 06.0	
385	" 4 "	15 19.5	149 22.5	1916.54	−2 28.5		
386	" 4 "	13 59.8	145 03.0	1916.57	−1 51.0		
387	" 4 "	16 53.8	144 18.8	1916.61		20 28.5	
388	" 3 "	18 16.0	144 07.7	1916.61	−0 44.0		
389		23 03.0	144 27.0	1916.62	0 30.0		
390	Mean of 3 tations	23 50.6	144 07.6	1916.62		31 54.0	
391	" 8 "	29 08.0	144 12.6	1916.63	2 27.0		

PACIFIC OCEAN, THE CARNEGIE'S CRUISE IV.

Station		Mean Spot		Date	Three Elements of Terrestrial Magnetism		
No.		Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	
392	Mean of 3 Stations	30 55.3	144 01.0	1916.62		42 14.0	
393	" 3 "	36 41.6	150 39.0	1916.63		48 58.0	
394	" 4 "	38 16.3	153 25.0	1916.64	2 34.5		
395	" 2 "	41 52.0	157 42.5	1916.64		53 54.0	
396	" 5 "	44 23.8	159 07.8	1916.64	1 32.4		
397	" 3 "	46 11.3	161 07.7	1916.65		58 00.0	
398	" 2 "	46 55.5	163 12.5	1916.65	0 18.0		
399	" 6 "	47 17.5	167 43.3	1916.65	−1 52.0		
400	" 5 "	47 35.4	170 03.8	19 6.66		59 19.2	
401	" 2 "	47 57.5	173 13.5	1916.66	−4 42.0		

TABLE 4.

ANNUAL MEANS AT THE MAGNETIC OBSERVATORIES IN AND AROUND THE PACIFIC OCEAN FOR 1902-1923.

Station				Date	Three Elements of Terrestrial Magnetism		
No.	Name	Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
501	Sitka (Canada) ...	57 03.	224 40.	1902	−29 51.1	74 47.8	15456
"	" ...	"	"	1903	" 53.9	" 46.3	15472
"	" ...	"	"	1904	" 55.8	" 45.4	15490
"	" ...	"	"	1905	" 59.1	" 43.2	15510
"	" ...	"	"	1906	−30 03.2	" 41.0	15529
"	" ...	"	"	1907	" 07.1	" 38.4	15545
"	" ...	"	"	1908	" 10.7	" 36.5	15562
"	" ...	"	"	1909	" 13.1	" 34.6	15576
"	" ...	"	"	1910	" 16.4	" 32.2	15593
"	" ...	"	"	1911	" 19.1	" 30.4	15606
"	" ...	"	"	1912	" 20.9	" 28.8	15615
"	" ...	"	"	1913	" 22.0	" 27.7	15606
"	" ...	"	"	1914	" 22.9	" 26.6	15605
"	" ...	"	"	1915	" 23.2	" 26.5	15593
"	" ...	"	"	1916	" 23.9	" 25.6	15585
"	" ...	"	"	1917	" 24.7	" 24.8	15584
"	" ...	"	"	1918	" 24.9	" 23.8	15580
"	" ...	"	"	1919	" 26.7	" 23.2	15578
"	" ...	"	"	1920	" 28.2	" 22.1	15574
502	Zinsen (Japan) ...	37 29.9	126 37.6	1921	5 26.5	53 19.9	
"	" ...	"	"	1922	" 31.3	" 13.8	
503	Tsingtau (China) ...	36 04.9	120 18.8	1904	3 40.2		
"	" ...	"	"	1906	" 40.2		
"	" ...	"	"	1907	" 41.7		
"	" ...	"	"	1908	" 43.6	52 21.5	30766
"	" ...	"	"	1909	" 44.5		
"	" ...	"	"	1910	" 49.5		
"	" ...	"	"	1911	" 53.1		
"	" ...	"	"	1912	" 54.5	52 07.3	30888
"	" ...	"	"	1916	4 04.7	" 07.1	30842
"	" ...	"	"	1917	" 07.0	" 06.1	30851

Station				Date	Three Elements of Terrestrial Magnetism		
No.	Name	Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
503	Tsingtau (China) ...	36 04.9	120 18.8	1918	4 08.2	52 06.9	30827
"	" ...	"	"	1919	4 09.9	" 07.4	30812
"	" ...	"	"	1920	" 12.9	" 07.0	30817
504	Lukiapang (China)	31 19.	121 02.	1908	2 57.3	45 35.1	33196
"	" ...	"	"	1909	" 58.6	" 34.9	33207
"	" ...	"	"	1910	3 01.1	" 34.4	33217
"	" ...	"	"	1911	" 02.5	" 33.9	33225
"	" ...	"	"	1912	" 04.6	" 32.9	33228
"	" ...	"	"	1913	" 07.2	" 32.6	33233
"	" ...	"	"	1914	" 09.5	" 31.7	33227
"	" ...	"	"	1915	" 13.2	" 32.1	33212
"	" ...	"	"	1916	" 16.0	" 31.9	33201
"	" ...	"	"	1917	" 17.8	" 31.5	33201
"	" ...	"	"	1918	" 18.8	" 31.0	33212
"	" ...	"	"	1919	" 20.0	" 30.96	33187
"	" ...	"	"	1920	" 21.4	" 30.7	33175
"	" ...	"	"	1922.93	" 26.6	" 29.86	33212
505	Taihoku (Japan) ...	25 02.3	121 30.8	1919	1 56.4		
"	" ...	"	"	1920	" 57.5		
"	" ...	"	"	1921	" 58.75		
"	" ...	"	"	1922	2 00.2		
"	" ...	"	"	1923	" 01.7		
506	Hongkong (China)...	22 18.	114 10.	1912	0 04.3	30 56.3	37206
"	" ...	"	"	1913	" 06.5	" 53.7	37166
"	" ...	"	"	1914	" 08.8	" 53.5	37184
"	" ...	"	"	1915	" 11.7	" 52.2	37166
"	" ...	"	"	1916	" 13.8	" 51.8	37144
"	" ...	"	"	1917	" 16.3	" 50.4	37163
"	" ...	"	"	1918	" 17.9	" 48.3	37164
"	" ...	"	"	1919	" 19.8	" 47.5	37171
"	" ...	"	"	1920	" 20.8	" 46.4	37191

TABLE 4

Station No.	Station Name	Latitude ° ′	Longitude ° ′	Date	Declination ° ′	Dip ° ′	Horizontal Intensity γ
506	Hongkong (China)...	22 18.	114 10.	1921	0 22.6	30 45.0	37190
"	" ...	"	"	1922	" 24.3	" 45.2	37174
507	Honolulu (Hawaiian Islands)	21 19.	201 56.	1902	−9 19.1	40 14.5	29284
"	" ...	"	"	1903	" 19.8	" 12.3	29257
"	" ...	"	"	1904	" 20.9	" 09.4	29237
"	" ...	"	"	1905	" 21.7	" 05.8	29226
"	" ...	"	"	1906	" 23.0	" 02.0	29220
"	" ...	"	"	1907	" 24.3	39 59.1	29201
"	" ...	"	"	1908	" 25.7	" 55.3	29188
"	" ...	"	"	1909	" 27.3	" 51.4	29167
"	" ...	"	"	1910	" 29.7	" 47.2	29161
"	" ...	"	"	1911	" 32.2	" 42.2	29139
"	" ...	"	"	1912	" 34.8	" 38.4	29214
"	" ...	"	"	1913	" 37.3	" 32.6	29075
"	" ...	"	"	1914	" 39.6	" 30.4	29045
"	" ...	"	"	1915	" 41.6	" 29.1	29005
"	" ...	"	"	1916	" 43.9	" 28.5	28966
"	" ...	"	"	1917	" 46.3	" 27.2	28935
"	" ...	"	"	1919	" 50.8	" 25.8	28871
"	" ...	"	"	1920	" 53.2	" 25.1	28847
508	Antipolo (Luzon) ..	14 36.	121 10.	1910	−0 39.8	16 17.2	38244
"	" ...	"	"	1911	" 40.9	" 18.2	38205
"	" ...	"	"	1914	" 38.8	" 10.6	38062
"	" ...	"	"	1915	" 37.3	" 11.2	38095
"	" ...	"	"	1916	" 37.3	" 09.8	38096
"	" ...	"	"	1917	" 35.9	" 07.7	38088
"	" ...	"	"	1918	" 35.5	" 05.0	38115
"	" ...	"	"	1919	" 36.1	15 54.2	
509	Buitenzorg (Java)...	−6 35.	106 47.	1902	−1 02.4	−30 17.6	36717
"	" ...	"	"	1903	−0 59.7	" 23.7	36696
"	" ...	"	"	1904	" 57.5	" 33.2	36697

Station				Date	Three Elements of Terrestrial Magnetism		
No.	Name	Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
509	Buitenzorg (Java) ...	−6 35.	106 47.	1905	−0 55.0	−30 39.7	36690
,,	,, ...	,,	,,	1906	,, 54.1	,, 48.5	36708
,,	,, ...	,,	,,	1907	,, 52.2	,, 55.2	36710
,,	,, ...	,,	,,	1908	,, 50.7	−31 02.4	36694
,,	,, ...	,,	,,	1909	,, 49.5	,, 09.2	36682
,,	,, ...	,,	,,	1910	,, 48.7	,, 12.0	36660
,,	,, ...	,,	,,	1911	,, 47.7	,, 16.4	36664
,,	,, ...	,,	,,	1912	,, 47.3	,, 19.4	36683
,,	,, ...	,,	,,	1916	,, 46.0	,, 38.4	36698
,,	,, ...	,,	,,	1918	,, 46.0	,, 46.2	36717
510	Apia (Samoan Islands)	−13 48.4	188 14.	1906.46	−9 38.7	−29 14.4	35682
,,	,, ...	,,	,,	1911.35	,, 45.5	,, 39.9	35531
,,	,, ...	,,	,,	1922	−10 13.6	−30 05.6	35241
511	Christchurch (New Zealand)	−43 32.	172 37.	1902	−16 15.1	−67 40.8	22694
,,	,, ...	,,	,,	1903	,, 18.3	,, 42.3	22669
,,	,, ...	,,	,,	1904	,, 21.8	,, 44.1	22644
,,	,, ...	,,	,,	1905	,, 25.4	,, 45.8	22628
,,	,, ...	,,	,,	1910	,, 37.6	,, 54.8	22515
,,	,, ...	,,	,,	1911	,, 39.0	,, 56.2	22494
,,	,, ...	,,	,,	1913	,, 44.0	,, 58.2	22449
,,	,, ...	,,	,,	1914	,, 44.8	,, 59.8	22414
,,	,, ...	,,	,,	1915	,, 47.0		22387
,,	,, ...	,,	,,	1916	,, 49.8		22355
,,	,, ...	,,	,,	1920	−17 01.7	−68 09.2	22261

TABLE 5.

RESULTS OF MAGNETIC OBSERVATIONS BY THE JAPANESE HYDROGRAPHIC DEPARTMENT FOR 1914–1923.

TISIMA

Station		Spot of Observation		Date	Three Elements of Terrestrial Magnetism		
No.	Name	Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
601	Syumusyu	50 43.3	156 12.6	1917.50	2 05.7		
602	Poromosiri	50 11.2	155 38.0	14.50	3 36.1		
603	„	50 03.1	155 13.3	14.50	4 05.0		
604	„	50 01.3	155 23.8	14.50	4 21.3		
605	Wonnekotan	49 36.7	154 49.2	15.50	* 2 09.3		
606	„	49 27.4	154 42.3	15.50	3 49.4		
607	„	49 26.5	154 48.4	15.50	* 1 40.8		
608	Syasukotan...	48 47.3	154 05.0	16.50	5 12.0		
609	„	48 46.9	154 03.7	16.50	5 03.3		
610	„	48 46.9	154 02.5	16.50	3 39.5		
611	„	48 46.9	154 01.9	16.50	5 47.3		
612	Matuwa	48 04.6	153 17.2	17.50	3 47.0		
613	„	48 02.7	153 13.7	17.50	3 39.0		
614	Ketoi	47 18.	152 29.	17.50	4 41.6		
615	Simusiri	47 09.	152 16.	17.50	4 54.7		
616	„	46 51.6	151 52.7	16.50	4 31.0		
617	„	46 50.9	151 53.4	16.50	4 49.0		
618	Uruppu	45 51.9	149 48.5	14.50	5 15.0		
619	„	45 49.7	149 54.1	14.50	5 19.0		
620	„	45 47.9	149 55.0	14.50	5 15.0		
621	„	45 37.0	149 28.2	14.50	5 12.0		
622	„	45 35.0	149 25.2	14.50	7 36.0		
623	Sikotan	43 52.0	146 49.7	23.54	6 02.0	57 57.5	25944
624	„	43 45.0	146 37.0	23.54	5 40.3	56 40.3	27037
625	„	43 39.0	146 20.0	23.54	5 24.2	57 12.3	26395
626	„	43 38.0	146 21.5	23.54	* -12 52.4	58 17.3	24607

KARAHUTO

		° ′	° ′		° ′		
627	Karahuto	54 21.2	142 40.2	1919.55	8 54.8		
628	„	54 19.3	142 35.7	19.56	9 38.5		
629	„	54 10.9	142 26.3	19.55	7 59.1		
630	„	53 42.2	142 35.6	19.61	9 07.2		
631	„	53 22.6	141 46.7	19.64	10 50.7		

KARAHUTO

Station		Spot of Observation		Date	Three Elements of Terrestrial Magnetism		
No.	Name	Latitude	Longitude		Declination	Dip	Horizontal Intensity
		° ′	° ′		° ′	° ′	γ
632	Karahuto	53 15.4	141 47.8	1919.50	7 06.0		
633	"	52 51.6	143 18.3	19.57	9 04.0	66 04.0	21970
634	"	52 44.	141 49.	20.50	10 36.6	66 16.0	
635	"	52 10.	141 40.	20.50	10 38.7	65 38.1	
636	"	51 58.5	143 11.0	19.53	9 14.7	65 14.0	22661
637	"	51 44.	141 45.	20.50	10 04.5	64 51.0	
638	"	50 54.3	143 38.3	19.62	8 36.5	64 13.0	23061
639	"	50 50.	142 09.	20.50	9 48.8	64 23.0	
640	"	50 22.1	143 46.6	19.64	8 01.0	64 06.0	23015
641	"	50 02.	142 08.	20.50	9 42.2	63 29.0	

TABLE 6.

RESULTS OF MAGNETIC OBSERVATIONS REPEATED FOUR TIMES AT THE SAME STATIONS IN JAPAN.

TABLE 6

Station No.	Station Name	Date	Declination °	Declination ′	Dip °	Dip ′	Horizontal Intensity γ
21	Ôdate	1887.58	5	15.7	54	12.5	27743
		1895.64	"	37.2	"	02.1	27932
		1912.71	6	24.2	"	04.7	28162
		1922.59	"	45.0	"	04.1	28093
22	Kuzi	1887.52	4	37.7	54	07.4	27983
		1895.54	5	03.6	"	01.2	28035
		1912.35	"	47.8	"	00.2	28291
		1922.56	6	15.0	"	03.9	28234
23	Akita	1887.59	5	09.3	53	37.6	28275
		1895.62	"	23.2	"	32.8	28301
		1912.72	6	10.4	"	33.3	28543
		1922.60	"	31.4	"	33.0	28520
27	Sakata	1887.60	5	11.0	52	51.9	28465
		1895.61	"	13.2	"	44.3	28651
		1912.76	"	57.5	"	40.8	28825
		1922.65	6	24.7	"	42.9	28816
28	Yamagata	1887.61	4	32.6	52	01.6	28651
		1895.59	"	45.0	51	56.6	28936
		1912.75	5	31.2	"	56.0	29102
		1922.66	6	01.5	"	50.7	29053
30	Niigata	1887.63	5	09.4	51	56.9	28699
		1895.62	"	17.2	"	57.0	28947
		1912.80	"	57.4	"	47.0	29102
		1922.68	6	18.2	"	43.5	29137
44	Obama	1887.75	4	54.1	49	30.4	30018
		1896.53	"	57.8	"	19.9	30096
		1912.34	5	23.1	"	14.0	30424
		1922.85	"	44.9	"	12.5	30435
46	Nagahama	1887.51	4	45.1	49	17.6	30026
		1895.12	"	48.0	"	07.7	30102
		1896.54	"	49.8	"	07.0	30116
		1913.27	5	19.6	"	01.7	30382
		1922.84	"	40.0	"	01.0	30370

Station		Date	Declination		Dip		Horizontal Intensity
No.	Name						
			°	′	°	′	γ
47	Imaiti	1887.73	4	48.9	50	13.1	30022
		1896.58	„	51.4	49	59.6	30295
		1913.37	5	20.0	„	49.3	30484
		1922.89	„	41.4	„	51.2	30511
54	Okayama	1887.57	4	38.1	48	47.9	30455
		1896.59	„	40.1	„	36.2	30572
		1913.21	5	12.3	„	35.7	30841
		1922.91	„	30.5	„	25.5	30892
56	Hirosima	1887.57	4	27.1	48	39.6	30714
		1896.50	„	33.5	„	25.5	30956
		1913.34	„	59.1	„	17.2	31169
		1922.92	5	20.1	„	15.4	31162
61	Tokusima	1887.52	4	26.0	48	00.4	30603
		1896.62	„	30.2	47	47.5	30829
		1913.09	„	55.9	„	38.7	30999
		1922.97	5	15.9	„	30.1	31017
67	Nakatu	1887.65	4	22.6	48	02.0	31000
		1896.64	„	26.3	47	53.6	31182
		1913.24	„	52.4	„	33.1	31488
		1923.11	5	09.4	„	37.0	31473
76	Miyazaki	1887.67	3	58.4	45	51.3	31562
		1896.52	„	57.6	„	37.2	31773
		1913.12	4	18.5	„	22.2	32106
		1923.09	„	32.0	„	23.8	32122

TABLE 7.

MEAN SECULAR ACCELERATION OF DECLINATION FOR 1896–1923.

TABLE 7

Station No.	Station Name	Date Latter / Former	Date Mean	Secular Variation Latter / Former	Mean Secular Acceleration
				′	′
8	Monbetu	1917.61 03.64	1910.63	3.29 3.31	−0.0014
11	Sibetu	1917.62 03.68	1910.65	3.13 4.25	−0.0803
12	Sapporo	1917.75 03.69	1910.72	2.97 2.81	0.0114
13	Siranuka...	1917.64 03.66	1910.65	3.27 2.97	0.0215
16	Setana	1917.44 03.48	1910.46	3.54 2.80	0.0530
17	Moyori	1917.64 03.64	1910.64	3.39 2.97	0.0300
18	Mori...	1917.67 03.70	1910.69	4.83 2.81	0.1446
19	Nohezi	1917.47 04.02	1910.75	2.01 2.89	−0.0654
20	Azigasawa	1917.64 04.16	1910.90	2.41 2.80	−0.0289
21	Ôdate	1917.65 04.18	1910.92	2.10 2.76	−0.0490
22	Kuzi...	1917.46 03.94	1910.70	2.66 2.63	0.0022
23	Akita	1917.66 04.17	1910.92	2.12 2.76	−0.0474
25	Mizusawa	1917.44 03.92	1910.68	2.38 2.43	−0.0037
30	Niigata	1917.74 04.21	1910.98	2.11 2.33	−0.0163
31	Wakamatu	1917.78 04.26	1911.02	1.95 2.53	−0.0429
33	Tôkamati	1917.76 03.22	1910.49	2.12 2.08	0.0028

Station		Date		Secular Variation	Mean Secular Acceleration
No.	Name	Latter / Former	Mean	Latter / Former	
				′	′
34	Itoigawa...	1917.77 03.30	1910.54	2.19 2.03	0.0111
37	Mito...	1918.00 04.22	1911.11	2.92 2.19	0.0530
39	Sioya	1917.53 03.03	1910.28	2.85 1.92	0.0641
40	Tyôsi	1918.18 04.39	1911.29	1.58 2.42	−0.0609
41	Hatiôzi	1918.22 03.94	1911.08	2.23 1.73	0.0350
43	Iida	1918.08 03.52	1910.80	2.46 1.80	0.0453
44	Obama	1917.60 04.44	1911.02	2.08 1.60	0.0365
45	Tottori	1918.07 04.90	1911.49	2.20 1.66	0.0410
46	Nagahama	1918.06 04.20	1911.13	2.13 1.74	0.0281
47	Imaiti	1918.13 04.98	1911.56	2.25 1.70	0.0418
48	Kuresaka	1918.12 04.96	1911.54	2.00 1.71	0.0220
54	Okayama	1918.06 04.90	1911.48	1.87 1.94	−0.0053
56	Hirosima...	1918.13 04.92	1911.53	2.19 1.52	0.0507
57	Sumoto	1918.03 04.85	1911.44	2.01 1.79	0.0167
58	Yamaguti	1918.22 04.91	1911.57	2.01 1.44	0.0428
59	Minabe	1918.10 04.92	1911.51	2.00 2.00	0.0000

Station		Date		Secular Variation	Mean Secular Acceleration
No.	Name	Latter / Former	Mean	Latter / Former	
				′	′
61	Tokusima	1918.03 04.86	1911.45	2.03 1.56	0.0357
62	Imaharu	1918.06 04.96	1911.51	2.29 1.43	0.0656
63	Ôsato	1918.03 04.87	1911.45	2.20 1.44	0.0578
64	Wakamiya	1918.05 04.92	1911.49	2.19 1.46	0.0556
65	Susaki	1918.04 04.90	1911.47	2.05 1.42	0.0479
67	Nakatu	1918.18 04.94	1911.56	1.72 1.57	0.0113
69	Saheki	1918.10 04.90	1911.50	1.75 1.46	0.0220
71	Simabara	1918.09 04.90	1911.50	1.81 1.40	0.0311
73	Zaikôzi	1918.11 04.82	1911.47	1.91 1.44	0.0354
74	Hitoyosi	1918.10 04.88	1911.49	1.83 0.65	0.0893
76	Miyazaki...	1918.11 04.82	1911.47	1.35 1.26	0.0068

TABLE 8.

MEAN SECULAR VARIATIONS OF DECLINATION, DIP, AND HORIZONTAL INTENSITY FOR 1913–1923 AND 1906–1917.

Remarks:

From No. 1 to 147 are the stations observed by the Hydrographic Department of the Japanese Navy.

From No. 201 to 218 are the stations observed by the Chinese Government latterly and the Carnegie Institution formerly.

From No. 304 to 325 are the stations observed by the Carnegie Institution.

TABLE 8

KARAHUTO

Station		Date		Declination		Dip		Horizontal Intensity	
No.	Name	Latter Former	Mean	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.
				° ′	′	° ′	′	γ	γ
1	Sikuka	1922.53 12.67	1917.60	8 46.7 „ 04.5	4.28	62 53.6 „ 50.9	0.27	23867 23912	−4.6
2	Usyoro	1922.48 12.78	1917.63	8 54.8 „ 22.4	3.34	62 35.2 „ 32.9	0.24	24111 24186	−7.7
4	Maoka	1922.46 12.56	1917.51	8 43.0 „ 06.8	3.65	60 50.4 „ 48.9	0.15	25096 25188	−9.3
5	Toyohara	1922.50 12.61	1917.56	8 37.1 7 56.1	4.15	60 42.4 „ 35.7	0.68	25162 25183	−2.1

HOKKAIDÔ

				° ′	′	° ′	′	γ	γ
8	Monbetu	1922.69 12.53	1917.61	7 31.8 6 58.3	3.29	57 58.9 „ 54.1	0.47	26366 26397	−3.1
11	Sibetu	1922.66 12.57	1917.62	6 51.4 „ 19.9	3.13	57 23.2 „ 21.8	0.14	26318 26364	−4.6
12	Sapporo	1922.65 12.84	1917.75	7 29.6 „ 00.5	2.97	57 03.9 „ 01.0	0.29	26773 26824	−5.2
13	Siranuka	1922.67 12.61	1917.64	6 30.2 5 57.3	3.27	56 38.5 „ 32.5	0.60	26864 26889	−2.5
16	Setana	1922.45 12.42	1917.44	7 29.6 6 54.1	3.54	56 19.8 „ 17.1	0.27	27436 27539	−10.3
17	Moyori	1922.63 12.64	1917.64	6 45.0 „ 11.2	3.39	55 46.9 „ 47.2	−0.03	27256 27315	−5.9
18	Mori...	1922.44 12.89	1917.67	7 17.0 6 30.8	4.83	56 06.6 55 53.8	1.34	27412 27452	−4.2

HONSYÛ

				° ′	′	° ′	′	γ	γ
19	Nohezi	1922.57 12.36	1917.47	7 01.1 6 40.6	2.01	54 37.3 „ 37.3	0.00	27874 27944	−6.9
20	Azigasawa ...	1922.58 12.69	1917.64	6 46.1 „ 22.3	2.41	54 47.5 „ 47.0	0.05	27955 28018	−6.4
21	Ôdate	1922.59 12.71	1917.65	6 45.0 „ 24.2	2.10	54 04.1 „ 04.7	−0.06	28093 28156	−6.4
22	Kuzi	1922.56 12.35	1917.46	6 15.0 5 47.8	2.66	54 03.9 „ 00.2	0.36	28234 28285	−5.0

HONSYÛ

Station		Date		Declination		Dip		Horizontal Intensity	
No.	Name	Latter Former	Mean	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.
				° ′	′	° ′	′	γ	γ
23	Akita...	1922.60 12.72	1917.66	6 31.4 „ 10.4	2.12	53 33.0 „ 33.3	−0.03	28520 28537	−1.7
24	Yokote	1922.65 12.74	1917.70	6 24.9 „ 03.1	2.20	52 58.6 53 00.3	−0.17	28749 28788	−3.9
25	Mizusawa	1922.55 12.33	1917.44	6 18.3 5 54.0	2.38	52 39.3 „ 36.2	0.30	28604 28647	−4.2
30	Niigata	1922.68 12.80	1917.74	6 18.2 5 57.4	2.11	51 43.5 „ 47.0	−0.35	29137 29096	4.1
31	Wakamatu ...	1922.67 12.88	1917.78	5 52.0 „ 32.9	1.95	51 10.5 „ 11.4	−0.09	29153 29166	−1.3
33	Tōkamati	1922.68 12.83	1917.76	6 00.9 5 40.1	2.12	50 58.7 51 00.5	−0.18	29504 29529	−2.5
34	Itoigawa	1922.69 12.84	1917.77	6 06.7 5 45.2	2.19	50 52.9 „ 55.7	−0.28	29490 29499	−0.9
35	Kuroiso	1922.44 13.32	1917.88	6 06.1 5 55.5	1.17	50 21.9 „ 27.3	−0.59	* 29437 29441	† −0.4
36	Ueda	1923.08 12.90	1917.99	5 36.3 „ 11.8	2.40	50 15.5 „ 20.6	−0.50	29399 29378	2.1
37	Mito	1923.08 12.91	1918.00	5 30.5 „ 00.8	2.92	49 38.5 „ 44.0	−0.54	29605 29613	−0.8
39	Sioya	1922.71 12.35	1917.53	6 07.0 5 37.5	2.85	50 19.7 „ 14.3	0.52	29940 29946	−0.6
40	Tyôsi...	1923.09 13.26	1918.18	5 12.3 4 56.8	1.58	48 26.4 „ 42.3	−1.62	30065 29953	11.4
41	Hatiôzi	1923.05 13.39	1918.22	5 28.3 „ 06.7	2.23	48 41.9 „ 49.3	−0.77	30001 29984	1.8
43	Iida	1922.83 13.32	1918.08	5 31.6 „ 08.2	2.46	48 51.5 49 01.3	−1.03	30123 30131	−0.8
44	Obama	1922.85 12.34	1917.60	5 44.9 „ 23.1	2.08	49 12.5 „ 14.0	−0.14	30435 30418	1.6
45	Tottori	1922.88 13.25	1918.07	5 54.8 „ 33.6	2.20	49 35.1 „ 37.8	−0.28	30499 30472	2.8
46	Nagahama ...	1922.84 13.27	1918.06	5 40.0 „ 19.6	2.13	49 01.0 „ 01.7	−0.07	30370 30376	−0.6

HONSYÛ

Station		Date		Declination		Dip		Horizontal Intensity	
No.	Name	Latter Former	Mean	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec Var.
				° ′	′	° ′	′	γ	γ
47	Imaiti	1922.89 13.37	1918.13	5 41.4 " 20.0	2.25	49 51.2 " 49.3	0.20	30511 30478	3.5
48	Kurosaka	1922.89 13.35	1918.12	5 41.8 " 22.7	2.00	49 18.9 " 12.0	0.72	30694 30685	0.9
51	Tomida	1923.03 13.17	1918.10	5 33.0 " 15.8	1.75	48 28.5 " 34.3	−0.59	30452 30439	1.3
52	Kakegawa ...	1923.04 13.15	1918.10	5 16.5 " 00.8	1.59	47 56.4 48 04.0	−0.77	30426 30432	−0.6
53	Toyohasi	1923.04 13.15	1918.10	5 24.5 " 08.0	1.66	48 10.2 " 17.5	−0.74	30432 30399	3.3
54	Okayama	1922.91 13.21	1918.06	5 30.5 " 12.3	1.87	48 25.5 " 35.7	−1.05	30892 30835	5.9
55	Miyagawa... ...	1923.02 13.18	1918.10	5 20.9 " 04.5	1.67	47 53.3 " 59.8	−0.66	30625 30601	2.4
56	Hirosima	1922.92 13.34	1918.13	5 20.1 4 59.1	2.19	48 15.4 " 17.2	−0.19	31162 31163	−0.1
57	Sumoto	1922.98 13.08	1918.03	5 21.1 " 01.2	2.01	47 51.8 " 58.9	−0.72	30915 30873	4.2
58	Yamaguti	1923.12 13.31	1918.22	5 15.7 4 56.0	2.01	48 10.0 " 06.7	0.34	31304 31296	0.8
59	Minabe	1922.99 13.21	1918.10	5 09.1 4 49.5	2.00	47 05.0 " 12.1	−0.73	31030 31024	0.6
60	Katuura	1923.01 13.20	1918.11	5 04.4 4 45.8	1.90	46 52.4 " 58.2	−0.59	31017 30965	5.3

SIKOKU

				° ′	′	° ′	′	γ	γ
61	Tokusima... ...	1922.97 13.09	1918.03	5 15.9 4 55.9	2.03	47 30.1 " 38.7	−0.87	31017 30993	2.4
62	Imaharu	1922.93 13.18	1918.06	5 19.1 4 56.8	2.29	47 48.3 " 54.1	−0.59	31165 31135	3.1
63	Ôsato	1922.96 13.10	1918.03	5 08.4 4 46.7	2.20	46 59.8 47 07.8	−0.81	31191 31184	0.7

SIKOKU

Station		Date		Declination		Dip		Horizontal Intensity	
No.	Name	Latter Former	Mean	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.
				° ′	′	° ′	′	γ	γ
64	Wakamiya ...	1922.94 13.15	1918.05	5 05.4 4 44.0	2.19	47 06.7 „ 15.7	−0.92	31372 31346	2.7
65	Susaki	1922.95 13.12	1918.04	5 04.4 4 44.2	2.05	46 54.3 47 02.2	−0.80	31340 31283	5.8

KYÛSYÛ

No.	Name	Latter Former	Mean	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.
				° ′	′	° ′	′	γ	γ
66	Izuhara	1922.94 13.26	1918.10	5 21.5 „ 03.8	1.83	48 40.2 „ 33.5	0.69	31373 31354	2.0
67	Nakatu	1923.11 13.24	1918.18	5 09.4 4 52.4	1.72	47 37.0 „ 33.1	0.40	31473 31482	−0.9
68	Karatu	1922.95 12.66	1917.81	5 01.3 4 39.4	2.13	47 33.0 „ 35.3	−0.22	31575 31574	0.1
69	Saheki	1923.10 13.10	1918.10	4 49.9 „ 32.4	1.75	46 47.8 „ 47.1	0.07	31570 31531	3.9
71	Simabara	1922.97 13.21	1918.09	4 45.4 „ 28.8	1.81	46 34.8 „ 33.2	0.16	31726 31698	2.9
73	Zaikôzi	1923.10 13.11	1918.11	4 43.0 „ 23.9	1.91	46 01.0 45 59.6	0.14	31895 31921	−2.6
74	Hitoyosi	1922.99 13.20	1918.10	4 36.5 „ 18.6	1.83	45 45.1 „ 39.1	0.61	32032 32034	−0.2
75	Usibuka	1922.99 12.73	1917.86	4 31.2 „ 13.1	1.76	46 49.6 45 47.3	† 6.07	32134 32100	3.3
76	Miyazaki	1923.09 13.12	1918.11	4 32.0 „ 18.5	1.35	45 23.8 „ 22.2	0.16	32122 32100	2.2
78	Makurazaki ...	1923.02 12.95	1917.99	3 54.5 „ 47.5	0.69	44 49.4 „ 50.8	−0.14	32232 32161	7.1
79	Nisi-no-Omote ...	1923.03 13.17	1918.10	4 08.6 3 51.0	1.79	43 42.7 „ 42.8	−0.01	32571 32542	2.9
80	Naze	1923.05 12.93	1917.99	3 24.3 „ 07.8	1.63	40 29.4 „ 30.5	−0.11	33528 33466	6.1

TYÔSEN

Station		Date		Declination		Dip		Horizontal Intensity	
No.	Name	Latter / Former	Mean	Latter / Former	Mean Sec. Var.	Latter / Former	Mean Sec. Var.	Latter / Former	Mean Sec. Var.
				° ′	′	° ′	′	γ	γ
81	Yûki	1922.64	1917.69	7 36.2	2.69	58 04.4	0.32		
		12.74		„ 09.6		„ 01.2			
84	Gisyû...	1922.56	1917.58	6 09.6	2.36	56 55.4	0.74	28448	1.5
		12.60		5 46.1		„ 48.0		28433	
85	Kisen...	1922.53	1917.59	6 33.1	2.39	56 26.3	0.77	28649	−6.7
		12.64		„ 08.3		„ 18.7		28715	
89	Heizyô	1922.52	1917.53	6 00.9	1.86	55 07.6	0.71	29349	0
		12.54		5 42.3		„ 00.5		29349	
92	Mukinpo	1922.50	1917.53	5 38.2	1.83	54 15.3	0.38	29736	−1.6
		12.55		„ 20.0		„ 11.5		29752	
93	Tyûmonzin ...	1922.67	1917.75	6 10.2	2.38	53 15.4	−0.63	29755	−3.5
		12.83		5 47.0		„ 21.5		29789	
94	Syunsen	1922.47	1917.48	6 05.2	1.86	53 30.2	0.09	29842	−1.1
		12.48		5 46.6		„ 29.3		29853	
95	Zinsen	1922.46	1917.48	5 39.4	1.11	53 08.8	−0.14	30036	2.8
		12.50		„ 28.4		„ 10.2		30008	
98	Gôsen...	1922.85	1917.67	5 35.4	2.50	51 49.8	0.30	30540	0.9
		12.48		„ 09.5		„ 46.7		30531	
99	Kôkan	1922.64	1917.52	5 29.4	1.57	51 20.3	0.01	30573	−4.0
		12.39		„ 13.3		„ 20.2		30614	
103	Sinsyû	1922.92	1917.78	5 06.3	1.91	50 04.1	−0.76	30994	−0.2
		12.64		4 46.6		„ 11.9		30996	
104	Kôsyû	1922.87	1917.65	5 10.7	2.82	50 10.8	0.39	31008	3.9
		12.42		4 41.2		„ 06.7		30967	
106	Moppo	1922.88	1917.66	4 50.2	2.40	49 42.6	−0.03	31324	2.7
		12.44		„ 25.1		„ 42.9		31296	
107	Kôyô...	1922.90	1917.64	4 54.7	1.16	49 51.0	1.93	31019	−8.6
		12.37		„ 42.5		„ 30.7		31110	
108	Hônan	1922.91	1917.64	4 29.9	2.52	49 21.3	−0.85	31272	1.2
		12.36		„ 03.3		„ 30.3		31259	

RYŪKYŪ

Station		Date		Declination		Dip		Horizontal Intensity	
No	Name	Latter Former	Mean	Latter Former	Mean Sec. Var.	Latter Former	Mean Sec. Var.	Later Former	Mean Sec. Var.
				° ′	′	° ′	′	γ	γ
111	Nago...	1923.07 12.87	1917.97	2 45.2 " 30.6	1.43	37 45.3 " 45.1	0.02	34353 34292	6.0
113	Miyako	1923.11 12.83	1917.97	2 03.8 1 50.2	1.33	35 00.4 " 03.5	−0.30	35253 35182	6.9

TAIWAN

				° ′	′	° ′	′	γ	γ †
115	Tansui	1922.95 13.09	1918.02	1 57.6 " 31.3	2.72	35 55.5 " 35.7	2.04	35349 35660	−32.1
117	Rokkô	1922.96 13.11	1918.04	1 20.5 " 04.8	1.63	33 35.9 34 05.7	−3.08	36012 35888	12.8
118	Kwarenkô... ...	1923.02 13.25	1918.14	1 22.1 " 09.8	1.26	33 41.0 " 49.5	−0.87	35979 35820	16.3
119	Hôkotô	1922.99 13.20	1918.10	0 53.9 " 40.7	1.37	32 45.6 " 56.7	−1.15	36370 36299	7.4
122	Taihanroku ...	1923.04 13.21	1918.13	0 57.3 " 43.8	1.37	29 59.3 30 09.1	−1.00	36754 36644	11.2

OGASAWARA

				° ′	′	° ′	′	γ	γ
124	Ômura	1922.47 13.42	1917.95	2 39.9 " 25.2	1.62	37 28.2 " 45.1	−1.87	31944 31808	15.0
128	Okimura	1922.50 13.40	1917.95	2 16.9 1 59.0	1.96	36 54.6 37 00.8	−0.68	32361 32321	4.4
129	Minamizaki ...	1922.50 13.40	1917.95	2 21.8 " 02.3	2 14	37 12.9 " 23.8	−1.20	32190 32151	4.3

MARIANA ISLANDS

Station No.	Station Name	Date Latter / Former	Date Mean	Declination Latter / Former	Mean Sec. Var.
				° ′	′
130	Pagan	1923.32 16.50	1919.91	−0 41.5 " 51.0	1.32
131	Saipan	1923.33 15.50	1919.42	−1 49.5 " 53.5	0.51

WEST CAROLINE ISLANDS

				° ′	′
133	Yap	1923.40 17.50	1920.45	−1 53.9 " 53.0	−0.15
136	Palau...	1923.38 18.50	1920.94	−2 19.1 " 30.0	2.23

EAST CAROLINE ISLANDS

				° ′	′
137	Olol	1923.43 16.50	1919.97	−3 57.7 −4 06.0	1.20
139	Wolea	1923.41 15.50	1919.46	−3 01.0 " 04.6	0.46
140	Truk...	1923.44 17.50	1920.47	−3 32.7 " 38.0	0.90
142	Ponape	1923.48 18.50	1920.99	−5 58.6 " 56.7	−0.38
143	Kusaie	1923.50 20.50	1922.00	−6 23.9 " 23.4	−0.17
144	Mortlock	1923.47 16.50	1919.99	−5 08.4 " 16.0	1.09

MARSHALL ISLANDS

				° ′	′
145	Brown	1923.55 17.50	1920.53	−6 19.3 " 20.0	0.11
146	Rongelab	1923.53 17.50	1920.52	−7 23.5 " 18.0	−1.00
147	Jaluit...	1923.52 15.50	1919.51	−8 03.8 −7 57.6	−0.78

CHINA

Station		Date		Declination	
No.	Name	Latter / Former	Mean	Latter / Forme	Mean Sec. Var.
				° ′	′
201	New chwang	1922.76 16.56	1919.66	5 44.4 " 27.6	2.71
202	Shanhaikwan	1922.74 16.53	1919.64	5 31.6 " 21.6	3.95
203	Tientsin	1922.71 16.49	1919.60	4 23.5 " 03.8	3.17
205	Tsinan	1922.93 15.62	1919.28	3 59.2 " 36.2	3.15
212	Hangchow	1923.09 17.83	1920.46	3 02.6 2 52.4	1.94
214	Ningpo	1922.41 17.85	1920.13	3 13.0 " 02.6	2.28
215	Wenchow	1922.90 17.86	1920.38	2 22.6 " 14.8	1.55
216	Foochow	1922.49 17.91	1920.20	1 53.8 " 42.6	2.44
217	Amoy	1922.45 17.92	1920.19	1 13.8 " 04.8	1.99
218	Swatow	1922.47 17.94	1920.21	0 55.0 " 45.1	2.18

CHINA

				° ′	′
304	Peking	1915.64 1909.02 1907.77	1910.37	3 55.3 " 30.1 " 38.4	2.83
306	Liangchowfu	1916.07 09.23	1912.65	−0 07.4 " 47.2	5.82
307	Sianfu	1915.97 09.13	1912.55	1 12.5 0 38.2	5.01
309	Wuhu	1911.67 07.68	1909.68	2 49.6 " 32.7	4.24
310	Soochow	1911.69 06.61	1909.15	2 40.1 " 30.1	1.97
311	Nanchang...	1911.61 08.90	1910.26	1 36.6 " 27.8	3.24
313	Shiuchow	1915.23 11.57	1913.40	0 46.7 " 34.8	3.25

CHINA

Station		Date		Declination	
No.	Name	Latter / Former	Mean	Latter / Former	Mean Sec. Var.
				° ′	′
314	Mengtsz	1917.36 11.85	1914.61	0 02.4 " 23.7	−3.87
315	Canton	1917.65 08.85	1910.25	0 11.4 " 05.6	2.07

PACIFIC ISLANDS

No.	Name	Latter / Former	Mean	Latter / Former	Mean Sec. Var.
				° ′	′
317	Guam, Cabras Island ...	1916.59 06.54	1911.57	−2 00.0 " 14.8	1.47
322	Papeete	1916.44 12.74	1914.59	−8 24.5 " 21.5	−0.81
323	Small Coral Island... ...	1916.44 07.11	1911.78	−10 09.5 −9 38.7	−3.30
324	Suva, Vou, A	1912.45 06.39	1909.42	−10 23.5 " 29.8	1.04
325	" Dr. Klotz's St. ...	1915.35 06.26	1910.81	−10 16.8 " 22.0	0.62

TABLE 9.

OBSERVED AND CALCULATED VALUES OF SECULAR VARIATIONS OF DECLINATION AND HORIZONTAL INTENSITY FOR 1913-1923, AND THEIR FIRST RESIDUALS.

Station		Secular Variation of Declination for 1918.0			Secular Variation of Horizontal Intensity for 1918.0		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		′	′	′	γ	γ	γ
1	Sikuka	4.28	2.74	1.54	−4.6	−8.1	3.5
2	Usyoro	3.34	2.75	0.59	−7.7	−8.1	0.4
4	Maoka	3.65	2.59	1.06	−9.3	−6.9	−2.4
5	Toyohara...	4.15	2.56	1.59	−2.1	−6.7	4.6
8	Monbetu	3.29	2.33	0.96	−3.1	−4.9	1.8
11	Sibetu	3.13	2.22	0.91	−4.6	−4.1	−0.5
12	Sapporo	2.97	2.28	0.69	−5.2	−4.3	−0.9
13	Siranuka	3.27	2.19	1.08	−2.5	−3.8	1.3
16	Setana	3.54	2.28	1.26	−10.3	−4.1	−6.2
17	Moyori	3.39	2.16	1.23	−5.9	−3.5	−2.4
18	Mori	4.83	2.23	2.60	−4.2	−3.8	−0.4
19	Nohezi	2.01	2.12	−0.11	−6.9	−2.8	−4.1
20	Azigasawa..	2.41	2.13	0.28	−6.4	−2.8	−3.6
21	Ôdate	2.10	2.09	0.01	−6.4	−2.4	−4.0
22	Kuzi	2.66	2.04	0.62	−5.0	−2.2	−2.8
23	Akita...	2.12	2.05	0.07	−1.7	−2.1	0.4
24	Yokote	2.20	2.01	0.19	−3.9	−1.8	−2.1
25	Mizusawa...	2.38	1.98	0.40	−4.2	−1.5	−2.7
30	Niigata	2.11	1.95	0.16	4.1	−0.8	4.9
31	Wakamatu	1.95	1.89	0.06	−1.3	−0.5	−0.8
33	Tōkamati...	2.12	1.89	0.23	−2.5	−0.2	−2.3
34	Itoigawa	2.19	1.91	0.28	−0.9	−0.2	−0.7
35	Kuroiso	1.17	1.82	−0.65			
36	Ueda...	2.40	1.82	0.58	2.1	0.1	2.0
37	Mito	2.92	1.79	1.13	−0.8	0.4	−1.2
39	Sioya...	2.85	1.90	0.95	−0.6	0.1	−0.7
40	Tyôsi...	1.58	1.73	−0.15	11.4	1.0	10.4
41	Hatiôzi	2.23	1.77	0.46	1.8	0.9	0.9
43	Iida	2.46	1.80	0.66	−0.8	0.8	−1.6
44	Obama	2.08	1.85	0.23	1.6	0.7	0.9
45	Tottori	2.20	1.99	0.21	2.8	0.6	2.2
46	Nagahama	2.13	1.83	0.30	−0.6	0.8	−1.4
47	Imaiti	2.25	1.91	0.34	3.5	0.6	2.9
48	Kurosaka...	2.00	1.88	0.12	0.9	0.8	0.1
51	Tomida	1.75	1.79	−0.04	1.3	1.1	0.2

Station		Secular Variation of Declination for 1918.0			Secular Variation of Horizontal Intensity for 1918.0		
No.	Name	Observed	Calculated	Residual (o—c)	Observed	Calculated	Residual (o—c)
		′	′	′	γ	γ	γ
52	Kakegawa	1.59	1.74	−0.15	−0.6	1.4	−2.0
53	Toyohasi	1.66	1.75	−0.09	3.3	1.4	1.9
54	Okayama	1.87	1.83	0.04	5.9	1.2	4.7
55	Miyagawa	1.67	1.75	−0.08	2.4	1.5	0.9
56	Hirosima	2.19	1.85	0.34	−0.1	1.4	−1.5
57	Sumoto	2.01	1.78	0.23	4.2	1.5	2.7
58	Yamaguti...	2.01	1.85	0.16	0.8	1.5	−0.7
59	Minabe	2.00	1.73	0.27	0.6	2.0	−1.4
60	Katuura	1.90	1.71	0.19	5.3	2.1	3.2
61	Tokusima...	2.03	1.77	0.26	2.4	1.7	0.7
62	Imaharu	2.29	1.81	0.48	3.1	1.6	1.5
63	Ôsato	2.20	1.75	0.45	0.7	2.0	−1.3
64	Wakamiya	2.19	1.78	0.41	2.7	2.1	0.6
65	Susaki	2.05	1.75	0.30	5.8	2.2	3.6
66	Izuhara	1.83	1.91	−0.08	2.0	1.5	0.5
67	Nakatu	1.72	1.82	−0.10	−0.9	2.0	−2.9
68	Karatu	2.13	1.83	0.30	0.1	2.1	−2.0
69	Saheki	1.75	1.76	−0.01	3.9	2.5	1.4
71	Simabara	1.81	1.77	0.04	2.9	2.6	0.3
73	Zaikôzi	1.91	1.72	0.19	−2.6	2.9	−5.5
74	Hitoyosi	1.83	1.72	0.11	−0.2	3.1	−3.3
75	Usibuka	1.76	1.74	0.02	3.3	3.1	0.2
76	Miyazaki	1.35	1.69	−0.34	2.2	3.3	−1.1
78	Makurazaki	0.69	1.66	−0.97	7.1	3.9	3.2
79	Nisi-no-Omote	1.79	1.61	0.18	2.9	4.3	−1.4
80	Naze	1.63	1.48	0.15	6.1	6.3	−0.2
81	Yûki	2.69	2.52	0.17			
84	Gisyû...	2.36	2.48	−0.12	1.5	−3.0	4.5
85	Kisen...	2.39	2.44	−0.05	−6.7	−3.0	−3.7
89	Heizyô	1.86	2.36	−0.50	0.0	−2.1	2.1
92	Mukinpo	1.83	2.31	−0.48	−1.6	−1.4	−0.2
93	Tyûmonzin	2.38	2.20	0.18	−3.5	−1.3	−2.2
94	Syunsen	1.86	2.22	−0.36	−1.1	−1.2	0.1
95	Zinsen	1.11	2.22	−1.11	2.8	−1.0	3.8
98	Gôsen	2.50	2.14	0.36	0.9	−0.2	1.1

Station		Secular Variation of Declination for 1918.0			Secular Variation of Horizontal Intensity for 1918.0		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		′	′	′	γ	γ	γ
99	Kôkan	1.57	2.08	−0.51	−4.0	0.0	−4.0
103	Sinsyû	1.91	2.00	−0.09	−0.2	0.7	−0.9
104	Kôsyû	2.82	2.03	0.79	3.9	0.8	3.1
106	Moppo	2.40	2.01	0.39	2.7	1.1	1.6
107	Kôyô...	1.16	1.98	−0.82	−8.6	1.2	−9.8
108	Hônan	2.52	1.97	0.55	1.2	1.3	−0.1
111	Nago...	1.43	1.38	0.05	6.0	7.8	−1.8
113	Miyako	1.33	1.31	0.02	6.9	9.5	−2.6
115	Tansui	2.72	1.40	1.32			
117	Rokkô	1.63	1.34	0.29	12.8	10.7	2.1
118	Kwarenkô	1.26	1.32	−0.06	16.3	10.6	5.7
119	Hôkotô	1.37	1.32	0.05	7.4	11.3	−3.9
122	Taihanroku	1.37	1.19	0.18	11.2	12.5	−1.3
124	Ômura	1.62	1.10	0.52	15.0	8.1	6.9
128	Okimura	1.96	1.07	0.89	4.4	8.5	−4.1
129	Minamizaki	2.14	1.07	1.07	4.3	8.5	−4.2
130	Pagan	1.32	0.48	0.84			
131	Saipan	0.51	0.32	0.19			
133	Yap	−0.15	0.20	−0.35			
136	Palau...	2.23	0.15	2.08			
137	Olol	1.20	−0.08	1.28			
139	Wolea	0.46	−0.01	0.47			
140	Truk	0.90	−0.19	1.09			
142	Ponape	−0.38	−0.36	−0.02			
143	Kusaie	−0.17	−0.55	0.38			
144	Mortlock	1.09	−0.29	1.38			
145	Brown	0.11	−0.29	0.40			
146	Rongelab	−1.00	−0.43	−0.57			
147	Jaluit...	−0.78	−0.72	−0.06			
201	Newchwang	2.71	2.58	0.13			
202	Shanhaikwan	3.95	2.56	1.39			
203	Tientsin	3.17	2.54	0.63			
205	Tsinan	3.15	2.34	0.81			
212	Hangchow	1.94	1.79	0.15			
214	Ningpo	2.28	1.73	0.55			

Station		Secular Variation of Declination for 1918.0			Secular Variation of Horizontal Intensity for 1918.0		
No	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		′	′	′			
215	Wenchow	1.55	1.61	−0.06			
216	Foochow	2.44	1.49	0.95			
217	Amoy	1.99	1.40	0.59			
218	Swatow	2.18	1.34	0.84			
304	Peking	2.83	2.62	0.21			
306	Liangchowfu	5.82	2.66	3.16			
307	Sianfu	5.01	2.27	2.74			
309	Wuhu	4.24	1.90	2.34			
310	Soochow	1.97	1.86	0.11			
311	Nanchang...	3.24	1.74	1.50			
313	Shiuchow	3.25	1.49	1.76			
314	Mengtsz	−3.87	1.49	−5.36†			
315	Canton	2.07	1.37	0.70			
317	Guam, Cabras, Island	1.47	0.26	1.21			
322	Papeete	−0.81	−2.55	1.74†			
323	Small Coral Island...	−3.30	−2.55	−0.75†			
324	Suva, Vou, A	1.04	−1.49	2.53†			
325	" Dr. Klotz's St.	0.62	−1.49	2.11†			
501	Sitka	−1.04	−0.78	−0.26			
503	Tsingtau	1.75	2.23	−0.48			
504	Lukiapang	1.47	1.85	−0.38			
506	Hongkong	1.82	1.30	0.52			
507	Honolulu	−2.29	−1.40	−0.89			
508	Antipolo	0.55	0.73	−0.18			
509	Buitenzorg	−0.12	−0.25	0.13			
510	Apia	−2.64	−1.49	−1.15			
511	Christchurch	−2.96	−1.29	−1.67			

TABLE 10.

OBSERVED AND CALCULATED VALUES OF FIRST RESIDUALS OF SECULAR VARIATION OF DECLINATION, AND THEIR SECOND RESIDUALS.

PART I

Station		Secular Variation of Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
1	Sikuka	1.54	1.57	−0.03
2	Usyoro	0.59	1.44	−0.85
4	Maoka	1.06	1.19	−0.13
5	Toyohara...	1.59	1.22	0.37
8	Monbetu	0.96	0.94	0.02
11	Sibetu	0.91	0.93	−0.02
12	Sapporo	0.69	0.72	−0.03
13	Siranuka	1.08	0.82	0.26
16	Setana	1.26	0.61	0.65
17	Moyori	1.23	0.74	0.49
18	Mori	2.60	0.61	1.99
19	Nohezi	−0.11	0.55	−0.66
20	Azigasawa	0.28	0.51	−0.23
21	Ôdate	0.01	0.50	−0.49
22	Kuzi	0.62	0.54	0.08
23	Akita	0.07	0.45	−0.38
24	Yokote	0.19	0.45	−0.26
25	Mizusawa...	0.40	0.46	−0.06
30	Niigata	0.16	0.35	−0.19
31	Wakamatu	0.06	0.37	−0.31
33	Tôkamati...	0.23	0.33	−0.10
34	Itoigawa	0.28	0.30	−0.02
35	Kuroiso	−0.65	0.37	−1.02
36	Ueda...	0.58	0.39	0.19
37	Mito	1.13	0.37	0.76
39	Sioya...	0.95	0.24	0.71
40	Tyôsi	−0.15	0.37	−0.52
41	Hatiôzi	0.46	0.34	0.12
43	Iida	0.66	0.30	0.36
44	Obama	0.23	0.23	0.00
45	Tottori	0.21	0.17	0.04
46	Nagahama	0.30	0.25	0.05
47	Imaiti	0.34	0.12	0.22

Station		Secular Variation of Declination.		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
48	Kurosaka...	0.12	0.15	−0.03
51	Tomida	−0.04	0.27	−0.31
52	Kakegawa	−0.15	0.31	−0.46
53	Toyohasi	−0.09	0.30	−0.39
54	Okayama...	0.04	0.19	−0.15
55	Miyagawa	−0.08	0.28	−0.36
56	Hirosima	0.34	0.15	0.19
57	Sumoto	0.23	0.23	0.00
58	Yamaguti	0.16	0.14	0.02
59	Minabe	0.27	0.26	0.01
60	Katuura	0.19	0.28	−0.09
61	Tokusima...	0.26	0.23	0.03
62	Imaharu	0.48	0.18	0.30
63	Ôsato	0.45	0.23	0.22
64	Wakamiya	0.41	0.17	0.24
65	Susaki	0.30	0.21	0.09
66	Izuhara	−0.08	0.09	−0.17
67	Nakatu	−0.10	0.12	−0.22
69	Saheki	−0.01	0.18	−0.19
81	Yûki	0.17	0.03	0.14
84	Gisyû	−0.12	−0.48	0.36
85	Kisen...	−0.05	−0.34	0.29
89	Heizyô	−0.50	−0.38	−0.12
92	Mukinpo	−0.48	−0.43	−0.05
93	Tyûmonzin	0.18	−0.15	0.33
94	Syunsen	−0.36	−0.22	−0.14
95	Zinsen	−1.11	−0.28	−0.83
99	Kôkan	−0.51	−0.16	−0.35
103	Sinsyû	−0.09	−0.11	0.02
124	Ômura	0.52	0.73	−0.21
128	Okimura	0.89	0.77	0.12
129	Minamizaki	1.07	0.78	0.29

PART II

Station		Secular Variation of Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
66	Izuhara	—0.08	—0.04	—0.04
67	Nakatu	—0.10	—0.07	—0.03
68	Karatu	0.30	—0.05	0.35
69	Saheki	—0.01	—0.04	0.03
71	Simabara...	0.04	0.02	0.02
73	Zaikôzi	0.19	—0.01	0.20
74	Hitoyosi	0.11	0.00	0.11
75	Usibuka	0.02	0.01	0.01
76	Miyazaki	—0.34	0.01	—0.35
78	Makurazaki	—0.97	0.04	—1.01
79	Nisi-no-Omote	0.18	0.05	0.13
80	Naze	0.15	0.09	0.06
84	Gisyû	—0.12	—0.32	0.20
89	Heizyô	—0.50	—0.28	—0.22
92	Mukinpo	—0.48	—0.14	—0.34
95	Zinsen	—1.11	—0.20	—0.91
98	Gôsen	0.36	—0.11	0.47
99	Kôkan	—0.51	—0.16	—0.35
103	Sinsyû	—0.09	—0.10	0.01
104	Kôsyû	0.79	—0.04	0.83
106	Moppo	0.39	0.01	0.38
107	Kôyô...	—0.82	—0.01	—0.81
108	Hônan	0.55	—0.02	0.57
111	Nago...	0.05	0.10	—0.05
113	Miyako	0.02	0.11	—0.09
115	Tansui	1.32	0.35	0.97
117	Rokkô	0.29	0.36	—0.07
118	Kwarenkô	—0.06	0.27	—0.33
119	Hôkotô	0.05	0.40	—0.35
122	Taihanroku	0.18	0.18	0.00
124	Ômura	0.52	0.37	0.15
128	Okimura	0.89	0.38	0.51
129	Minamizaki	1.07	0.38	0.69

Station		Secular Variation of Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
201	Newchwang	0.13	−0.14	0.27
202	Shanhaikwan	1.39	0.19	1.20
203	Tientsin	0.63	0.61	0.02
205	Tsinan	0.81	0.80	0.01
212	Hangchow	0.15	0.60	−0.45
214	Ningpo	0.55	0.46	0.09
215	Wenchow...	−0.06	0.52	−0.58
216	Foochow	0.95	0.59	0.36
217	Amoy	0.59	0.60	−0.01
218	Swatow	0.84	0.67	0.17
304	Peking	0.21	0.65	−0.44
306	Liangchowfu	3.16	3.66	−0.50
307	Sianfu	2.74	2.27	0.47
309	Wufu...	2.34	0.79	1.55
310	Soochow	0.11	0.54	−0.43
311	Nanchang	1.50	1.06	0.44
313	Shiuchow...	1.76	1.21	0.55
315	Canton	0.70	1.08	−0.38
503	Tsingtau	−0.48	0.42	−0.90
504	Lukiapang	−0.38	0.51	−0.89
506	Hongkong	0.52	0.88	−0.36

PART III

		′	′	′
1	Sikuka	1.54	0.89	0.65
2	Usyoro	0.59	0.84	−0.25
4	Maoka	1.06	0.83	0.23
5	Toyohara...	1.59	0.85	0.74
8	Monbetu	0.96	0.85	0.11
11	Sibetu	0.91	0.85	0.06
13	Siranuka	1.08	0.85	0.23
17	Moyori	1.23	0.82	0.41
22	Kuzi...	0.62	0.76	−0.14
36	Ueda...	0.58	0.70	−0.12

Station		Secular Variation of Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
37	Mito	1.13	0.69	0.44
40	Tyôsi	−0.15	0.69	−0.84
41	Hatiôzi	0.46	0.65	−0.19
52	Kakegawa	−0.15	0.61	−0.76
53	Toyohasi	−0.09	0.59	−0.68
55	Miyagawa	−0.08	0.56	−0.64
59	Minabe	0.27	0.52	−0.25
60	Katuura	0.19	0.54	−0.35
63	Ôsato	0.45	0.48	−0.03
65	Susaki	0.30	0.44	−0.14
69	Saheki	−0.01	0.39	−0.40
73	Zaikôzi	0.19	0.38	−0.19
76	Miyazaki	−0.34	0.38	−0.72
79	Nisi-no-Omote	0.18	0.36	−0.18
80	Naze	0.15	0.32	−0.17
111	Nago	0.05	0.27	−0.22
113	Miyako	0.02	0.18	−0.16
115	Tansui	1.32	0.01	1.31
117	Rokkô	0.29	−0.02	0.31
118	Kwarenkô	−0.06	0.04	−0.10
119	Hôkotô	0.05	−0.05	0.10
122	Taihanroku	0.18	0.02	0.16
124	Ômura	0.52	0.67	−0.15
128	Okimura	0.89	0.67	0.22
129	Minamizaki	1.07	0.67	0.40
130	Pagan	0.84	0.65	0.19
131	Saipan	0.19	0.63	−0.44
133	Yap	−0.35	0.57	−0.92
136	Palau	2.08	0.54	1.54
137	Olol	1.28	0.57	0.71
139	Wolea	0.47	0.59	−0.12
140	Truk	1.09	0.54	0.55
142	Ponape	−0.02	0.43	−0.45
143	Kusaie	0.38	0.28	0.10
144	Mortlock	1.38	0.49	0.89

Station		Secular Variation of Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
145	Brown	0.40	0.41	−0.01
146	Rongelab	−0.57	0.29	−0.86
147	Jaluit...	−0.06	0.06	−0.12
317	Guam, Cabras, Island	1.21	0.62	0.59
501	Sitka...	−0.26	−0.12	−0.14
507	Honolulu	−0.89	−1.04	0.15
508	Antipolo	−0.18	0.14	−0.32
509	Buitenzorg	0.13	0.10	0.03
510	Apia...	−1.15	−1.66	0.51
511	Christchurch	−1.67	−1.17	−0.50

TABLE 11.

OBSERVED VALUES OF DECLINATION AND THE SAME REDUCED TO 1923.0.

Station No.	Station Name	Direct Observed Value °	Direct Observed Value ′	Reduction to 1923.0 ′	Reduced Observed Value °	Reduced Observed Value ′
1	Sikuka	8	46.7	02.0	8	48.7
2	Usyoro	"	54.8	01.7	"	56.5
3	Higasi-Siraoro	"	18.0	01.9	"	19.9
4	Maoka	"	43.0	02.0	"	45.0
5	Toyohara	"	37.1	02.1	"	39.2
6	Ôtomari	"	17.1	01.5	"	18.6
7	Wakkanai	"	20.5	01.0	"	21.5
8	Monbetu	7	31.8	01.0	7	32.8
9	Rumoi	"	41.1	01.2	"	42.3
10	Asahikawa	"	48.1	01.2	"	49.3
11	Sibetu	6	51.4	01.1	6	52.5
12	Sapporo	7	29.6	01.0	7	30.6
13	Siranuka	6	30.2	01.1	6	31.3
14	Ikeda	"	47.5	01.0	"	48.5
15	Saruhuto	7	17.0	01.1	7	18.1
16	Setana	"	29.6	01.9	"	31.5
17	Moyori	6	45.0	01.3	6	46.3
18	Mori	7	17.0	02.7	7	19.7
19	Nohezi	"	01.1	00.9	"	02.0
20	Azigasawa	6	46.1	01.0	6	47.1
21	Ôdate	"	45.0	00.9	"	45.9
22	Kuzi	"	15.0	01.2	"	16.2
23	Akita	"	31.4	00.8	"	32.2
24	Yokote	"	24.9	00.8	"	25.7
25	Mizusawa	"	18.3	01.1	"	19.4
26	Yonegasaki	"	11.8	01.1	"	12.9
27	Sakata	"	24.7	00.8	"	25.5
28	Yamagata	"	01.5	00.8	"	02.3
29	Sendai	"	07.0	01.1	"	0.81
30	Niigata...	"	18.2	00.7	"	18.9
31	Wakamatu	5	52.0	00.6	5	52.6
32	Wazima	6	10.5	00.7	6	11.2
33	Tôkamati	"	00.9	00.7	"	01.6
34	Itoigawa	"	06.7	00.7	"	07.4
35	Kuroiso	"	06.1	00.7	"	06.8

Station No.	Station Name	Direct Observed Value		Reduction to 1923.0	Reduced Observed Value	
		°	′	′	°	′
36	Ueda	5	36.3	−00.2	5	36.1
37	Mito	„	30.5	−00.2	„	30.3
38	Matuida	„	48.9	−00.2	„	48.7
39	Sioya	6	07.0	00.8	6	07.8
40	Tyôsi	5	12.3	−00.1	5	12.2
41	Hatiôzi	„	28.3	−00.1	„	28.2
42	Miyazu	„	44.9	00.3	„	45.2
43	Iida	„	31.6	00.4	„	32.0
44	Obama	„	44.9	00.3	„	45.2
45	Tottori	„	54.8	00.3	„	55.1
46	Nagahama	„	40.0	00.3	„	40.3
47	Imaiti	„	41.4	00.2	„	41.6
48	Kurosaka	„	41.8	00.2	„	42.0
49	Yunotu	„	14.2	00.2	„	14.4
50	Kamikamo	„	32.8	00.3	„	33.1
51	Tomida	„	33.0	−00.1	„	32.9
52	Kakegawa	„	16.5	−00.1	„	16.4
53	Toyohasi	„	24.5	−00.1	„	24.4
54	Okayama	„	30.5	00.2	„	30.7
55	Miyagawa	„	20.9	00.0	„	20.9
56	Hirosima	„	20.1	00.2	„	20.3
57	Sumoto	„	21.1	00.0	„	21.1
58	Yamaguti	„	15.7	−00.2	„	15.5
59	Minabe	„	09.1	00.0	„	09.1
60	Katuura	„	04.4	00.0	„	04.4
61	Tokusima	„	15.9	00.1	„	16.0
62	Imaharu	„	19.1	00.2	„	19.3
63	Ôsato	„	08.4	00.1	„	08.5
64	Wakamiya	„	05.4	00.1	„	05.5
65	Susaki	„	04.4	00.1	„	04.5
66	Izuhara	„	21.5	00.1	„	21.6
67	Nakatu	„	09.4	−00.2	„	09.2
68	Karatu	„	01.3	00.1	„	01.4
69	Saheki	4	49.9	−00.2	4	49.7
70	Miyazi	„	34.2	00.0	„	34.2

Station No.	Station Name	Direct Observed Value °	Direct Observed Value ′	Reduction to 1923.0 ′	Reduced Observed Value °	Reduced Observed Value ′
71	Simabara	4	45.4	00.1	4	45.5
73	Zaikôzi	"	43.0	−00.2	"	42.8
74	Hitoyosi	"	36.5	00.0	"	36.5
75	Usibuka	"	31.2	00.0	"	31.2
76	Miyazaki	"	32.0	−00.1	"	31.9
77	Nisi-Itiki	3	59.2	00.0	3	59.2
78	Makurazaki...	"	54.5	00.0	"	54.5
79	Nisi-no-Omote	4	08.6	−00.1	4	08.5
80	Naze	3	24.3	−00.1	3	24.2
81	Yûki	7	36.2	01.0	7	37.2
82	Zyôsin	"	03.7	00.9	"	04.6
83	Hokusei	6	47.8	00.8	6	48.6
84	Gisyû	"	09.6	01.0	"	10.6
85	Kisen	"	33.1	01.1	"	34.2
86	Kizyô	"	19.7	01.0	"	20.7
87	Eikô	"	28.5	00.9	"	29.4
88	Genzan...	"	28.5	00.8	"	29.3
89	Heizyô	"	00.9	00.9	"	01.8
90	Tyôzen	5	26.1	00.7	5	26.8
91	Zuikô	"	52.2	01.0	"	53.2
92	Mukinpo	"	38.2	00.9	"	39.1
93	Tyûmonzin	6	10.2	01.0	6	11.2
94	Syunsen	"	05.2	01.0	"	06.2
95	Zinsen	5	39.4	00.6	5	40.0
96	Tikuhen	"	37.2	00.6	"	37.8
97	Tyûsyû...	"	33.7	00.8	"	34.5
98	Gisen	"	35.4	00.4	"	35.8
99	Kôkan	"	29.4	00.6	"	30.0
100	Hokô	"	40.9	00.4	"	41.3
101	Taikyû...	"	37.9	00.3	"	38.2
102	Zensyû	"	21.3	00.2	"	21.5
103	Sinsyû	"	06.3	00.2	"	06.5
104	Kôsyû	"	10.7	00.4	"	11.1
105	Huzan	"	21.1	00.5	"	21.6
106	Moppo	4	50.2	00.3	4	50.5

Station No.	Station Name	Direct Observed Value		Reduction to 1923.0	Reduced Observed Value	
		°	′	′	°	′
107	Kôyô	4	54.7	00.1	4	54.8
108	Hônan	„	29.9	00.2	„	30.1
109	Pu-lan-tien	5	25.2	00.2	5	25.4
110	Chou-shui-tzu	„	14.9	00.2	„	15.1
111	Nago	2	45.2	−00.1	2	45.1
112	Naha	„	27.5	−00.1	„	27.4
113	Miyako...	„	03.8	−00.1	„	03.7
114	Isigaki	1	55.2	−00.2	1	55.0
115	Tansui	„	57.6	00.6	„	58.2
116	Taihoku	„	59.5	00.4	„	59.9
117	Rokkô	„	20.5	00.3	„	20.8
118	Kwarenkô	„	22.1	00.0	„	22.1
119	Hôkotô...	0	53.9	00.2	0	54.1
120	Tainan	1	10.2	00.3	1	10.5
121	Pinan	„	06.4	00.0	„	06.4
122	Taihanroku	0	57.3	−00.1	0	57.2
123	Okumura	2	39.8	00.9	2	40.7
124	Ômura	„	39.9	00.9	„	40.8
125	Ôgiura	3	04.2	00.9	3	05.1
126	Higasiminato	2	37.4	00.8	2	38.2
127	Kitamura	„	35.4	00.8	„	36.2
128	Okimura	„	16.9	01.0	„	17.9
129	Minamizaki	„	21.8	01.1	„	22.9
130	Pagan	−0	41.5	−00.4	−0	41.9
131	Saipan	−1	49.5	−00.2	−1	49.7
132	„	„	35.5	−00.2	„	35.7
133	Yap	„	53.9	00.1	„	53.8
134	Palau	−2	10.1	−00.1	−2	10.2
135	„	„	00.0	−00.1	„	00.1
136	„	„	19.1	−00.8	„	19.9
137	Olol	−3	57.7	−00.5	−3	58.2
138	Truk	−5	32.8	00.0	−5	32.8
139	Wolea	−3	01.0	−00.2	−3	01.2
140	Truk	„	32.7	−00.4	„	33.1
141	Lossop	−4	35.5	00.1	−4	35.4

Station No.	Station Name	Direct Observed Value °	Direct Observed Value ′	Reduction to 1923.0 ′	Reduced Observed Value °	Reduced Observed Value ′
142	Ponape	−5	58.6	00.2	−5	58.4
143	Kusaie	−6	23.9	00.1	−6	23.8
144	Mortlock	−5	08.4	−00.5	−5	c8.9
145	Brown	−6	19.3	−00.1	−6	19.4
146	Rongelab	−7	23.5	00.5	−7	23.0
147	Jaluit	−8	03.8	00.4	−8	03.4
201	New-chwang	5	44.4	00.7	5	45.1
202	Shanhaikwan	”	31.6	01.1	”	32.7
203	Tientsin	4	23.5	00.9	4	24.4
204	Chefoo	5	00.3	00.8	5	01.1
205	Tsinan	3	59.2	00.2	3	59.4
206	Yangchow Residence... ...	”	22.1	01.6	”	23.7
207	” Hospital	”	21.8	01.6	”	23.4
2c8	Chinkiang Residence... ...	”	29.1	01.7	”	30.8
209	” Vict. Park.. ...	”	27.6	01.8	”	29.4
210	Nanking	2	38.2	01.8	2	40.0
211	Woosung	3	21.3	01.4	3	22.7
212	Hangchow	”	02.6	—00.2	”	02.4
213	Putu	”	31.6	01.9	”	33.5
214	Ningpo	”	13.0	01.3	”	14.3
215	Wenchow	2	22.6	00.2	2	22.8
216	Foochow	1	53.8	01.2	1	55.0
217	Amoy	”	13.8	01.1	”	14.9
218	Swatow...	0	55.0	01.2	0	56.2
301	Mean of 3 Stations	6	48.0	21.8	7	09.8
302	” 6 ”	7	43.1	16.3	”	59.4
303	” 23 ”	6	01.5	15.0	6	16.5
304	Peking	3	55.3	26.8	4	22.1
305	Mean of 22 Stations	4	00.2	22.6	”	22.8
308	Suchow, An...	2	57.3	22.2	3	19.5
309	Wuhu	”	49.6	48.0	”	37.6
310	Soochow	”	40.1	22.3	”	02.4
311	Nanchang	1	36.6	36.9	2	13.5
312	Mean of 30 Stations	”	41.8	12.1	1	53.9
316	Guam, Orote Point	−1	56.8	02.7	−1	54.1

Station No.	Station Name	Direct Observed Value °	Direct Observed Value ′	Reduction to 1923.0 ′	Reduced Observed Value °	Reduced Observed Value ′
317	Guam, Cabras, Island. ...	−2	00.0	09.4	−1	50.6
318	" Sumay	−1	59.1	02.6	"	56.5
319	Maraki Island	−8	54.1	−07.4	−9	01.5
320	Apaiang	"	46.4	−07.4	−8	53.8
321	Tarawa	"	55.0	−07.5	−9	02.5
326	Mean of 5 Stations	−2	46.2	−01.1	−2	47.3
328	" 3 "	−3	08.6	−00.9	−3	09.5
330	" 6 "	−2	23.3	01.6	−2	21.7
332	" 5 "	−0	48.0	06.2	−0	41.8
334	" 19 "	"	11.1	10.1	"	01.0
336	" 3 "	2	10.6	14.4	2	25.0
338	" 3 "	3	22.7	19.0	3	41.7
340	" 3 "	2	34.0	18.7	2	52.7
341	" 3 "	0	25.0	15.3	0	40.3
342	" 4 "	−2	11.0	09.0	−2	02.0
344	" 6 "	−6	47.8	02.1	−6	45.7
347	" 3 "	−8	30.0	−03.6	−8	33.6
349	" 3 "	"	45.0	−07.0	"	52.0
351	" 5 "	−4	31.2	13.6	−4	17.6
353	" 6 "	−1	48.0	13.2	−1	34.8
355	" 6 "	−0	31.0	12.5	−0	18.5
357	" 7 "	−2	24.0	08.1	−2	15.9
358	" 4 "	−5	21.0	04.6	−5	16.4
360	" 11 "	−6	33.8	02.2	−6	31.6
365	" 12 "	"	51.0	−00.1	"	51.1
368	" 10 "	"	52.8	−01.5	"	54.3
371	" 13 "	"	58.6	−03.1	−7	01.7
376	" 15 "	−7	10.0	−04.5	"	14.5
378	" 5 "	−8	32.4	−02.7	−8	35.1
380	" 5 "	−6	56.4	−00.7	−6	57.1
382	" 8 "	−4	39.0	01.4	−4	37.6
383	" 4 "	−3	15.0	02.3	−3	12.7
385	" 4 "	−2	28.5	02.8	−2	25.7
386	" 4 "	−1	51.0	02.8	−1	48.2
388	" 3 "	−0	44.0	05.4	−0	38.6

Station No.	Station Name	Direct Observed Value °	Direct Observed Value ′	Reduction to 1923.0 ′	Reduced Observed Value °	Reduced Observed Value ′
389		0	30.0	09.1	0	39.1
391	Mean of 8 Stations	2	27.0	10.9	2	37.9
394	" 4 "	"	34.5	12.0	"	46.5
396	" 5 "	1	32.4	13.1	1	45.5
398	" 2 "	0	18.0	12.3	0	30.3
399	" 6 "	−1	52.0	10.5	−1	41.5
401	" 2 "	−4	42.0	09.2	−4	32.8
503	Tsingtau (China)	4	16.3	00.3	4	16.6
504	Lukiapang (China)	3	26.6	00.1	3	26.7
506	Hongkong (China)	0	24.3	01.8	0	26.1
508	Antipolo (Luzon)...	−0	36.1	02.2	−0	33.9
601	Syumusyu	2	05.7	16.2	2	21.9
602	Poromosiri	3	36.1	25.0	4	01.1
603	"	4	05.0	25.2	"	30.2
604	"	"	21.3	25.0	"	46.3
606	Onnekoton	3	49.4	22.4	"	11.8
608	Syasukotan	5	12.0	19.5	5	31.5
609	"	"	03.3	19.5	"	22.8
610	"	3	39.5	19.5	3	59.0
611	"	5	47.3	19.5	6	06.8
612	Matuwa	3	47.0	16.7	4	03.7
613	"	"	39.0	16.6	3	55.6
614	Ketoi	4	41.6	16.7	4	58.3
615	Simusiri	"	54.7	16.9	5	11.6
616	"	"	31.0	20.3	4	51.3
617	"	"	49.0	20.2	5	09.2
618	Uruppu	5	15.0	28.4	"	43.4
619	"	"	19.0	28.4	"	47.4
620	"	"	15.0	28.4	"	43.4
621	"	"	12.0	28.9	"	40.9
622	"	7	36.0	28.9	8	04.9
623	Sikotan...	6	02.0	−01.7	6	00.3
624	"	5	40.3	−01.7	5	38.6
625	"	"	24.2	−01.7	"	22.5
627	Karahuto	8	54.8	16.4	9	11.2

Station		Direct Observed Value		Reduction to 1923.0	Reduced Observed Value	
No.	Name	°	′	′	°	′
628	Karahuto	9	38.5	16.3	9	54.8
629	"	7	59.1	16.2	8	15.3
630	"	9	07.2	15.8	9	23.0
631	"	10	50.7	15.4	11	06.1
632	"	7	06.0	15.9	7	21.9
633	"	9	04.0	15.9	9	19.9
634	"	10	36.6	11.3	10	47.9
635	"	"	38.7	11.0	"	49.7
636	"	9	14.7	15.6	9	30.3
637	"	10	04.5	10.9	10	15.4
638	"	8	36.5	14.7	8	51.2
639	"	9	48.8	10.5	9	59.3
640	"	8	01.0	14.1	8	15.1
641	"	9	42.2	10.2	9	52.4

TABLE 12.

OBSERVED AND CALCULATED VALUES
OF DECLINATION, DIP, AND HORIZONTAL INTENSITY
FOR 1923.0,
AND THEIR FIRST RESIDUALS.

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		° ′	° ′	′	° ′	° ′	′	γ	γ	γ
1	Sikuka	8 48.7	8 10.1	38.6	62 53.6	65 19.6	−146.0	23867	24032	−165
2	Usyoro	„ 56.5	„ 14.9	41.6	„ 35.2	„ 08.7	−153.5	24111	24186	−75
3	Higasi-Siracro	„ 19.9	7 54.3	25.6	61 37.1	63 52.7	−135.6	24571	24685	−114
4	Maoka	„ 45.0	„ 45.9	59.1	60 50.4	„ 01.6	−131.2	25096	25062	34
5	Toyohara ...	„ 39.2	„ 38.7	60.5	„ 42.4	62 47.5	−125.1	25162	25116	46
6	Ôtomari ...	„ 18.6	„ 33.3	45.3	„ 23.8	„ 24.7	−120.9	25304	25265	39
7	Wakkanai ...	„ 21.5	„ 24.0	57.5	59 18.9	61 09.2	−110.3	25961	25819	142
8	Monbetu ...	7 32.8	6 52.6	40.2	57 58.9	59 32.8	−93.9	26366	26321	45
9	Rumoi	„ 42.3	7 01.5	40.8	„ 56.8	„ 20.6	−83.8	26598	26491	107
10	Asahikawa ...	„ 49.3	6 52.3	57.0	„ 37.1	58 58.1	−81.0	26540	26582	−42
11	Sibetu	6 52.5	„ 24.1	28.4	„ 23.2	„ 25.6	−62.4	26318	26643	−325
12	Sapporo... ...	7 30.6	„ 50.3	40.3	„ 03.9	„ 17.4	−73.5	26773	26882	−109
13	Siranuka ...	6 31.3	„ 24.2	07.1	56 38.5	57 41.9	−63.4	26864	26941	−77
14	Ikeda	„ 48.5	„ 30.2	18.3	„ 37.1	„ 46.4	−69.3	26859	26945	−86
15	Saruhuto ...	7 18.1	„ 36.3	41.8	„ 36.5	„ 28.5	−52.0	26995	27121	−126
16	Setana	„ 31.5	„ 51.6	39.9	„ 19.8	„ 45.7	−85.9	27436	27164	272
17	Moyori	6 46.3	„ 21.4	24.9	55 46.9	56 58.7	−71.8	27256	27221	35
18	Mori	7 19.7	„ 41.3	38.4	56 06.6	57 11.5	−64.9	27412	27309	103
19	Nohezi	„ 02.0	„ 18.5	43.5	54 37.3	55 29.9	−52.6	27874	27832	42
20	Azigasawa ...	6 47.1	„ 23.4	23.7	„ 47.5	„ 30.7	−43.2	27955	27887	68
21	Ôdate	„ 45.9	„ 13.6	32.3	„ 04.1	54 48.2	−44.1	28093	28089	4
22	Kuzi	„ 16.2	„ 03.0	13.2	„ 03.9	„ 30.2	−26.3	28234	28105	129
23	Akita	„ 32.2	„ 06.7	25.5	53 33.0	„ 06.6	−33.6	28520	28335	185
24	Yokote	„ 25.7	5 57.9	27.8	52 58.6	53 32.3	−33.7	28749	28479	270
25	Mizusawa ...	„ 19.4	„ 51.0	28.4	„ 39.3	„ 12.2	−32.9	28604	28544	60
26	Yonegasaki ...	„ 12.9	„ 45.0	27.9	„ 46.9	52 57.0	−10.1	28362	28587	−225
27	Sakata	„ 25.5	„ 57.6	27.9	„ 42.9	53 05.3	−22.4	28816	28665	151
28	Yamagata ...	„ 02.3	„ 44.4	17.9	51 50.7	52 07.3	−16.6	29053	28916	137
29	Sendai	„ 08.1	„ 40.5	27.6	„ 51.2	„ 01.8	−10.6	28781	28907	−126
30	Niigata	„ 18.9	„ 47.3	31.6	„ 43.5	51 50.3	−06.8	29137	29093	44
31	Wakamatu ...	5 52.6	„ 35.2	17.4	„ 10.5	„ 06.5	04.0	29153	29234	−81
32	Wazima... ...	6 11.2	„ 49.3	21.9	„ 15.6	„ 25.4	−09.8	29587	29389	198
33	Tôkamati ...	„ 01.6	„ 37.0	24.6	50 58.7	50 47.6	11.1	29504	29413	91
34	Itoigawa ...	„ 07.4	„ 39.9	27.5	„ 52.9	„ 46.9	06.0	29490	29488	2
35	Kuroiso	„ 06.8	„ 26.6	40.2†	„ 21.9	„ 22.1	−00.2			

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calcu-lated	Residual (o—c)	Observed	Calcu-lated	Residual (o—c)	Ob-served	Calcu-lated	Residual (o—c)
		° ′	° ′	′	° ′	° ′	′	γ	γ	γ
36	Ueda	5 36.1	5 20.7	15.4	50 15.5	50 11.6	03.9	29399	29432	−33
37	Mito	„ 30.3	„ 14.9	15.4	49 38.5	49 29.5	09.0	29605	29646	−41
38	Matuida... ...	„ 48.7	„ 24.1	24.6	„ 39.0	„ 36.8	02.2	29844	29737	107
39	Sioya	6 07.8	„ 34.8	33.0	50 19.7	„ 57.3	22.4	29940	29863	77
40	Tyôsi	5 12.2	„ 01.5	10.7	48 26.4	48 31.9	−05.5	30065	29878	187
41	Hatiôzi	„ 28.2	„ 11.1	17.1	„ 41.9	„ 36.7	05.2	30001	29964	37
42	Miyazu	„ 45.2	„ 26.1	19.1	49 19.3	49 00.4	18.9	30438	30223	215
43	Iida	„ 32.0	„ 16.9	15.1	48 51.5	48 36.4	15.1	30123	30086	37
44	Obama	„ 45.2	„ 24.3	20.9	49 12.5	„ 53.1	19.4	30435	30203	232
45	Tottori	„ 55.1	„ 27.6	27.5	„ 35.1	49 06.9	28.2	30499	30291	208
46	Nagahama ..	„ 40.3	„ 20.7	19.6	„ 01.0	48 37.0	24.0	30370	30225	145
47	Imaiti	„ 41.6	„ 26.7	14.9	„ 51.2	49 08.3	42.9	30511	30449	62
48	Kurosaka ...	„ 42.0	„ 24.0	18.0	„ 18.9	48 48.4	30.5	30694	30468	226
49	Yunotu	„ 14.4	„ 22.8	−08.4†	„ 53.9	„ 49.0	64.9	30447	30583	−136†
50	Kamikamo ...	„ 33.1	„ 17.3	15.8	48 40.9	„ 13.1	27.8	30573	30377	196
51	Tomida	„ 32.9	„ 13.7	19.2	„ 28.5	„ 00.8	27.7	30452	30348	104
52	Kakegawa ...	„ 16.4	„ 04.7	11.7	47 56.4	47 30.2	26.2	30426	30361	65
53	Toyohasi ...	„ 24.4	„ 07.2	17.2	48 10.2	„ 33.7	36.5	30432	30400	32
54	Okayama ...	„ 30.7	„ 15.3	15.4	„ 25.5	„ 55.9	29.6	30892	30641	251
55	Miyagawa ...	„ 20.9	„ 06.3	14.6	47 53.3	„ 17.8	35.5	30625	30533	92
56	Hirosima ...	„ 20.3	„ 11.7	08.6	48 15.4	„ 43.5	31.9	31162	30861	301
57	Sumoto	„ 21.1	„ 08.6	12.5	47 51.8	„ 17.5	34.3	30915	30708	207
58	Yamaguti ...	„ 15.5	„ 08.2	07.3	48 10.0	„ 34.6	35.4	31304	31017	287
59	Minabe	„ 09.1	4 58.8	10.3	47 05.0	46 21.8	43.2	31030	30901	129
60	Katuura... ..	„ 04.4	„ 55.2	09.2	46 52.4	„ 04.9	47.5	31017	30911	106
61	Tokusima ..	„ 16.0	5 05.0	11.0	47 30.1	„ 55.7	34.4	31017	30835	182
62	Imaharu ...	„ 19.3	„ 06.7	12.6	„ 48.3	47 09.4	38.9	31165	30946	219
63	Ôsato	„ 08.5	4 59.7	08.8	46 59.8	46 24.3	35.5	31191	31049	142
64	Wakamiya ...	„ 05.5	„ 58.6	06.9	47 06.7	„ 24.4	42.3	31372	31190	182
65	Susaki	„ 04.5	„ 56.2	08.3	46 54.3	„ 05.2	49.1	31340	31188	152
66	Izuhara	„ 21.6	5 04.2	17.4	48 40.2	48 01.4	38.8	31373	31186	187
67	Nakatu	„ 09.2	4 59.2	10.0	47 37.0	46 45.5	51.5	31473	31266	207
68	Karatu	„ 01.4	„ 55.0	06.4	„ 33.0	„ 44.1	48.9	31575	31428	147
69	Saheki	4 49.7	„ 49.7	00.0	46 47.8	45 38.1	69.7	31570	31464	106
70	Miyazi	„ 34.2	„ 48.8	−14.6†	„ 52.2	„ 43.9	68.3	31624	31536	88†

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		° ′	° ′	′	° ′	° ′	′	γ	γ	γ
71	Simabara ...	4 45.5	4 45.5	00.0	46 34.8	45 43.6	51.2	31726	31657	69
72	Nagasaki ...							31246	31713	−467†
73	Zaikôzi	4 42.8	4 41.2	01.6	46 01.0	44 50.3	70.7	31895	31694	201
74	Hitoyosi	„ 36.5	„ 37.4	−00.9	45 45.1	„ 40.7	64.4	32032	31841	191
75	Usibuka... ...	„ 31.2	„ 35.5	−04.3				32134	31919	215
76	Miyazaki ...	„ 31.9	„ 33.6	−01.7	45 23.8	44 06.6	77.2	32122	31897	225
77	Nisi-Itiki ...	3 59.2	„ 28.4	−29.2†	„ 10.8	43 54.5	76.3	32127	32089	38
78	Makurazaki ...	„ 54.5	„ 22.0	−27.5†	44 49.4	„ 14.9	94.5	32232	32248	−16†
79	Nisi-no-Omote	4 08.5	„ 15.0	−06.5	43 42.7	42 18.1	84.6	32571	32379	192
80	Naze	3 24.2	3 35.9	−11.7	40 29.4	38 40.4	109.0	33528	33384	144
81	Yûki	7 37.2	7 15.1	22.1	58 04.4	59 36.1	−91.7	27613	27482	131
82	Zyôsin	„ 04.6	6 47.7	16.9	56 41.0	57 34.7	−53.7	28364	28338	26
83	Hokusei	6 48.6	„ 38.6	10.0	„ 10.8	„ 10.3	−59.5	28618	28595	23
84	Gisyû	„ 10.6	„ 20.8	−10.2	„ 55.4	58 07.7	−72.3	28448	28869	−421
85	Kisen	„ 34.2	„ 29.2	05.0	„ 26.3	57 36.9	−70.6	28649	28768	−119
86	Kizyô	„ 20.7	„ 20.5	00.2	„ 17.7	„ 36.2	−78.5	28762	28920	−158
87	Eikô	„ 29.4	„ 23.9	05.5	55 37.7	56 26.6	−48.9	28890	28990	−100
88	Genzan	„ 29.3	„ 17.4	11.9	„ 01.8	55 50.5	−48.7	29200	29154	46
89	Heizyo	„ 01.8	„ 07.2	−05.4	„ 07.6	56 02.3	−54.7	29349	29355	−6
90	Tyôzen	5 26.8	„ 13.3	−46.5†	54 27.0	55 03.1	−36.1	29347	29298	49
91	Zuikô	„ 53.2	„ 00.5	−07.3	„ 18.6	„ 06.2	−47.6	29630	29583	47
92	Mukinpo ..	„ 39.1	5 48.8	−09.7	„ 15.3	„ 03.2	−47.9	29736	29816	−80
93	Tyûmonzin ...	6 11.2	6 01.8	09.4	53 15.4	53 40.0	−24.6	29755	29636	119
94	Syunsen... ...	„ 06.2	5 57.8	08.4	„ 30.2	„ 53.2	−23.0	29842	29730	112
95	Zinsen	5 40.0	„ 47.6	−07.6	„ 08.8	„ 34.3	−25.5	30036	29981	55
96	Tikuhen... ...	„ 37.8	„ 50.1	−12.3†	52 12.6	52 19.1	−06.5	30078	29965	113
97	Tyûsyû	„ 34.5	„ 44.2	−09.7†	„ 03.2	„ 28.6	−25.4	30161	30120	41
98	Gôsen	„ 35.8	„ 30.2	05.6†	51 49.8	51 59.6	−09.8	30540	30467	73
99	Kôkan	„ 30.0	„ 32.2	−02.2	„ 20.3	„ 17.4	02.9	30573	30456	117
100	Hokô	„ 41.3	„ 33.9	07.4	„ 01.3	50 47.2	14.1	30482	30409	73
101	Taikyû	„ 38.2	„ 29.0	09.2	50 42.0	„ 40.6	01.4	30727	30549	178
102	Zensyû	„ 21.5	„ 23.3	−01.8	„ 59.1	„ 56.6	02.5	30770	30681	89
103	Sinsyû	„ 06.5	„ 17.2	−10.7	„ 04.1	49 46.1	18.0	30994	30868	126
104	Kôsyû	„ 11.1	„ 11.6	−00.5	„ 10.8	„ 56.2	14.6	31008	30995	13
105	Huzan	„ 21.6	„ 18.2	03.4	49 41.0	„ 24.7	16.3	31185	30838	347

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o—c)	Observed	Calculated	Residual (o—c)	Observed	Calculated	Residual (o—c)
		° ′	° ′	′	° ′	° ′	′	γ	γ	γ
106	Moppo	4 50.5	5 03.5	−13.0	49 42.6	49 28.9	13.7	31324	31199	125
107	Kôyô	" 54.8	" 04.6	−09.8	" 51.0	" 00.7	50.3	31019	31196	−177†
108	Hônan	" 30.1	" 03.4	−33.3	" 21.3	48 54.4	26.9	31272	31228	44
109	Pu-lan-tien ...	5 25.4	" 48.6	−23.2	56 15.2	57 38.2	−83.0	28900	29471	−571
110	Chou-shui-tzu	" 15.1	" 38.0	−22.9	55 40.7	" 04.7	−84.0	29294	29726	−432
111	Nago	2 45.1	3 03.8	−18.7	37 45.3	35 53.9	111.4	34353	34179	174
112	Naha	" 27.4	2 56.6	−29.2	" 10.9	" 17.2	113.7	34563	34349	214
113	Miyako	" 03.7	" 22.7	−19.0	35 00.4	33 10.2	110.2	35253	35141	112
114	Isigaki	1 55.0	" 07.6	−12.6	34 11.2	32 29.3	101.9	35594	35467	127
115	Tansui	" 58.2	1 57.8	00.4	35 55.5	34 24.4	91.1			
116	Taihoku... ...	" 59.9	" 56.5	03.4	" 25.5	" 08.9	76.6	35806	35622	184†
117	Rokkô	" 20.8	" 30.6	−09.8	33 35.9	32 32.8	63.1	36012	36143	−131
118	Kwarenkô ...	" 22.1	" 41.0	−18.9	" 41.0	" 13.7	87.3	35979	35979	0
119	Hôkotô	0 54.1	" 13.8	−19.7†	32 45.6	31 49.3	56.3	36370	36454	−84
120	Tainan	1 10.5	" 11.9	−01.4	31 52.7	30 40.5	72.2	36531	36544	−13
121	Pinan	" 06.4	" 17.8	−11.4	" 29.2	" 04.4	84.8	36488	36470	18
122	Taihanroku ...	0 57.2	" 01.7	−04.5	29 59.3	28 40.1	79.2	36754	36798	−44
123	Okumura ...	2 40.7	2 46.1	−05.4	36 54.1	35 35.0	79.1	32025	32626	−601
124	Ômura	" 40.8	" 46.1	−05.3	37 28.2	" 34.4	113.8	31944	32629	−685
125	Ôgiura	3 05.1	" 45.8	19.3†	" 27.7	" 32.8	114.9	32220	32634	−414
126	Higasiminato	2 38.2	" 40.7	−02.5	" 06.8	34 56.8	130.0	32165	32744	−579
127	Kitamura ...	" 36.2	" 40.7	−04.5	36 53.7	" 56.6	117.1	31818	32745	−927
128	Okimura ...	" 17.9	" 39.8	−21.9	" 54.6	" 51.5	123.1	32361	32759	−398
129	Minamizaki ...	" 22.9	" 39.5	−16.6	37 12.9	" 49.9	143.0	32190	32762	−572
130	Pagan	−0 41.9	0 08.8	−50.7	22 31.9	20 57.8	94.1	33372	34386	−1014
131	Saipan	−1 49.7	−0 30.6	−79.1	17 28.3	15 53.9	94.4	34385	34871	−486
132	"	" 35.7	" 31.5	−64.2	" 25.9	" 47.4	98.5	34373	34877	−504
133	Yap	" 53.8	" 58.9	−54.9	5 45.0	4 36.8	68.2	36740	36730	10
134	Palau	−2 10.2	−1 22.7	−47.5	1 30.1	−0 01.3	91.4	37448	37660	−212
135	"	" 00.1	" 22.7	−37.4	" 27.8	" 01.7	89.5	36835	37654	−819
136	"	" 19.9	" 22.8	−57.1	" 20.9	" 02.5	83.4	37361	37659	−298
137	Olol...	−3 58.2	−2 42.1	−76.1	5 36.3	4 24.7	71.6	35234	35120	114
138	Truk	−5 32.8	−3 28.2	−124.6†	0 47.6	2 36.2	−108.6	33843	34902	−1059†
139	Wolea ...	−3 01.2	−1 59.5	−61.7	2 02.6	1 08.5	54.1	36191	36033	158
140	Truk	" 33.1	−3 27.7	−05.4†	" 05.1	2 34.1	−29.0	35668	34904	764

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		° ′	° ′	′	° ′	° ′	′	γ	γ	γ
141	Lossop	−4 35.4	−3 46.0	−49.4	1 39.2	1 53.1	−13.9	34995	34816	179
142	Ponape	−5 58.4	−5 20.1	−38.3	2 45.2	3 01.7	−16.5	34959	34181	778
143	Kusaie	−6 23.8	−7 21.1	57.3	„ 31.9	1 46.5	45.4	34207	33674	533
144	Mortlock ...	−5 08.9	−4 20.9	−48.0	−0 40.0	−0 48.7	08.7	35500	34732	768
145	Brown	−6 19.4	−5 52.4	−27.0	12 08.8	12 08.0	00.8	33154	33688	−534
146	Rongelab ...	−7 23.0	−7 47.8	24.8	13 31.0	13 03.3	27.7	32333	33396	−1063
147	Jaluit	−8 03.4	−10 06.1	122.7	4 43.7	5 01.3	−17.6	34194	33132	1062
201	Newchwang ...	5 45.1	6 10.0	−24.9	57 49.7	59 30.7	−101.0	28180	28829	−649
202	Shanhaikwan	„ 32.7	5 38.0	−05.3†	„ 04.3	„ 09.0	−124.7	28842	29382	−540
203	Tientsin	4 24.4	4 55.3	−30.9	56 25.1	58 37.1	−132.0	29211	30084	−873
204	Chefoo	5 01.1	5 10.2	−09.1†	53 50.2	54 56.9	−66.7	30146	30426	−280
205	Tsinan	3 59.4	4 12.9	−13.5	„ 04.2	„ 49.6	−105.4	30803	31326	−523
206	Yangchow Resid.	„ 23.7	3 32.4	−08.7	47 15.6	47 13.4	02.2	32774	33001	−227
207	„ Hospital	„ 23.4	„ 32.0	−08.6	„ 14.2	„ 12.3	01.9	32812	33009	−197
208	Chinkiang Resid. .	„ 30.8	„ 29.4	01.4	46 54.7	46 56.8	−02.1	32970	33079	−109
209	„ Vict. Park	„ 29.4	„ 29.0	00.4	„ 58.9	„ 55.1	03.8	33020	33087	−67
210	Nanking... ...	2 40.0	„ 19.5	−39.5†	„ 46.4	„ 48.8	−02.4	32941	33240	−299
211	Woosung ...	3 22.7	„ 36.6	−13.9	45 34.4	45 05.0	29.4	33236	33168	68
212	Hangchow ...	„ 02.4	„ 06.0	−03.6	44 01.7	43 36.1	25.6	33746	33788	−42
213	Putu	„ 33.5	„ 22.3	11.2	43 52.2	42 34.7	77.5	33907	33625	282†
214	Ningpo	„ 14.3	„ 13.0	01.3	„ 23.4	„ 34.3	49.1	33723	33771	−48
215	Wenchow ...	2 22.8	2 34.9	−12.1	40 47.1	39 33.5	73.6	34354	34638	−284
216	Foochow ..	1 55.0	1 50.3	04.7	37 29.6	36 20.0	69.6	35518	35597	−79
217	Amoy	„ 14.9	„ 10.1	04.8	34 55.6	33 41.0	74.6	36133	36393	−260
218	Swatow	0 56.2	0 35.2	21.0	32 40.0	31 56.8	43.2	36815	37030	−215
301	Mean of 3 Stations	7 09.8	8 11.2	−61.4	67 01.0	72 15.5	−314.5			
302	„ 6 „	„ 59.4	„ 04.6	−05.2	62 59.4	66 11.9	−192.5			
303	„ 23 „	6 16.5	6 28.0	−11.5	58 06.0	60 02.6	−116.6			
304	Peking	4 22.1	4 59.9	−37.8						
305	Mean of 22 Stations	„ 22.8	5 07.2	−44.4	57 09.2	59 42.5	−153.3			
308	Suchow. An ...	3 19.5	3 23.4	−03.9	49 00.7	49 57.5	−56.8			
309	Wuhu	„ 37.6	„ 02.8	34.8†	45 43.6	45 45.5	−01.9			
310	Soochow... ...	„ 02.4	„ 27.2	−24.8†	„ 47.6	„ 11.5	36.1			
311	Nanchang ...	2 13.5	1 48.7	24.8	41 52.2	41 46.7	05.5			
312	Mean of 30 Stations	1 53.9	„ 45.2	08.7†	38 49.0	38 10.7	38.3			

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o—c)	Observed	Calculated	Residual (o—c)	Observed	Calculated	Residual (o—c)
		° ′	° ′	′	° ′	° ′	′			
316	Guam, Orote Point	−1 54.1	−0 41.9	−72.2	14 05.4	12 55.4	70.0			
317	„ Cabras Island	„ 50.6	„ 44.3	−66.3	„ 03.6	„ 39.5	84.1			
318	„ Sumay	„ 56.5	„ 44.6	−71.9	„ 02.9	„ 36.1	86.8			
319	Maraki Island	−9 01.5	−12 39.2	217.7	−2 11.6	−0 29.0	−102.6			
320	Apaiang... ...	−8 53.8	„ 32.6	218.8	−1 49.9	„ 52.1	−57.8			
321	Tarawa	−9 02.5	„ 35.6	213.1	−3 13.3	−1 47.9	−85.4			
326		−2 47.3	−3 01.4	14.1						
327					−12 36.2	−13 59.5	83.3			
328		−3 09.5	−2 35.1	−34.4						
329					−5 54.0	−7 06.5	72.5			
330		−2 21.7	−1 29.8	−51.9						
331					5 40.7	4 00.4	100.3			
332		−0 41.8	0 03.2	−45.0						
333					17 52.7	15 46.8	125.9			
334		−0 01.0	0 00.2	−01.2						
335					26 27.4	25 03.9	83.5			
336		2 25.0	3 00.4	−35.4						
337					37 23.3	35 09.9	133.4			
338		3 41.7	4 01.6	−19.9						
339					42 35.8	41 13.3	82.5			
340		2 52.7	3 12.9	−20.2						
341		0 40.3	1 38.7	−58.4						
342		−2 02.0	−0 46.8	−75.2						
343					41 29.6	40 46.3	43.3			
344		−6 45.7	−6 07.2	−38.5						
345					36 13.5	34 38.2	95.3			
346					28 55.5	27 01.9	113.6			
347		−8 33.6	−9 32.1	58.5						
348					21 35.5	19 47.9	107.6			
349		−8 52.0	−12 03.2	191.2†						
350					65 30.0	66 58.3	−88.3			
351		−4 17.6	−1 29.3	−168.3						
352					61 33.0	63 09.5	−96.5			
353		−1 34.8	0 01.9	−96.7						
354					57 09.0	58 43.0	−94.0			

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		° ′	° ′	′	° ′	° ′	′			
355		−0 18.5	1 05.0	−83.5						
356					50 42.0	51 31.3	−49.3			
357		−2 15.9	−1 05.5	−70.4						
358		−5 16.4	−4 24.4	−52.0						
359					44 46.5	44 37.8	08.7			
360		−6 31.6	−5 46.8	−44.8						
361					40 27.1	39 58.4	28.7			
362					36 42.0	35 45.2	56.8			
363					30 42.0	28 54.1	107.9			
364					30 30.0	29 05.7	84.3			
365		−6 51.1	−6 15.6	−35.5						
366					27 06.0	25 55.6	70.4			
367					20 36.0	19 28.7	67.3			
368		−6 54.3	−6 28.2	−26.1						
369					18 09.0	16 54.9	74.1			
370					12 16.0	12 13.0	03.0			
371		−7 01.7	−6 59.3	−02.4						
372					7 51.0	7 26.6	24.4			
373					3 27.0	3 26.2	00.8			
374					−0 38.0	−0 28.9	−09.1			
375					−3 28.0	−2 43.7	−44.3			
376		−7 14.5	−7 37.8	23.3						
377					−7 36.0	−7 02.5	−33.5			
378		−8 35.1	−9 54.0	78.9						
379					24 51.6	22 50.2	121.4			
380		−6 57.1	−6 18.6	−38.5						
381					26 50.4	25 45.5	64.9			
382		−4 37.6	−3 17.7	−79.9						
383		−3 12.7	−1 48.7	−84.0						
384					19 06.0	17 36.5	89.5			
385		−2 25.7	−1 09.8	−75.9						
386		−1 48.2	−0 40.6	−67.6						
387					20 28.5	18 43.6	104.9			
388		−0 38.6	0 25.9	−64.5						
389		0 39.1	1 30.3	−51.2						

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)	Observed	Calculated	Residual (o−c)
		° ′	° ′	′	° ′	° ′	′	γ	γ	γ
390					31 54.0	30 18.4	95.6			
391		2 37.9	2 59.1	−21.2						
392					42 14.0	41 20.4	53.6			
393					48 58.0	49 04.2	−06.2			
394		2 46.5	3 06.9	−20.4						
395					53 54.0	55 07.8	−73.8			
396		1 45.5	2 41.7	−56.2						
397					58 00.0	59 42.1	−102.1			
398		0 30.3	1 39.9	−69.6						
399		−1 41.5	−0 19.6	−81.9						
400					59 19.2	60 53.2	−94.0			
401		−4 32.8	−3 04.9	−87.9						
503	Tsingtau ...	4 16.6	4 40.1	−23.5	52 09.8	52 58.8	−49.0	30856	31227	−371
504	Lukiapang ...	3 26.7	3 30.6	−03.9	45 29.9	45 04.3	25.6	33212	33194	18
506	Hongkong ...	0 26.1	−0 17.7	43.8						
508	Antipolo... ...	−0 33.9	−0 45.9	12.0	15 54.2	14 30.1	84.1			
601	Syumusyu ...	2 21.9	5 16.6	−174.7†						
602	Poromosiri ...	4 01.1	" 20.8	−79.7†						
603		" 30.2	" 26.9	−56.7†						
604	Poromosiri ...	" 46.3	" 23.0	−36.7†						
606	Onnekotan ...	" 11.8	" 28.0	−76.2†						
608	Syasukotan ...	5 31.5	" 29.6	01.9†						
609	" ...	" 22.8	" 29.9	−07.1†						
610	" ...	3 59.0	" 30.3	−91.3†						
611	" ...	6 06.8	" 30.4	36.4†						
612	Matuwa... ...	4 03.7	" 32.8	−89.1†						
613	"	3 55.6	" 33.4	−97.8†						
614	Ketoi	4 58.3	" 35.8	−37.5†						
615	Simusiri... ...	5 11.6	" 37.2	−25.6†						
616	"	4 51.3	" 39.4	−48.1†						
617	"	5 09.2	" 39.0	−29.8†						
618	Uruppu	" 43.4	" 57.1	−13.7†						
619	"	" 47.4	" 55.1	−07.7†						
620	"	" 43.4	" 54.4	−11.0†						
621	"	" 40.9	" 58.4	−17.5†						

Station		Declination			Dip			Horizontal Intensity		
No.	Name	Observed	Calcu-lated	Residual (o−c)	Observed	Calcu-lated	Residual (o−c)	Ob-served	Calcu-lated	Residual (o−c)
		° ′	° ′	′	° ′	° ′	′			
622	Uruppu	8 04.9	5 58.5	126.4†						
623	Sikotan	6 00.3	6 06.8	−06.5	57 57.5	58 25.9	−28.4			
624	„	5 38.6	„ 07.6	−29.0†	56 40.3	„ 19.2	−98.9			
625	„	„ 22.5	„ 09.5	−47.0†	57 12.3	„ 14.3	−62.0			
627	Karahuto ...	9 11.2	9 35.0	−23.8†						
628	„ ...	„ 54.8	„ 35.3	19.5†						
629	„ ...	8 15.3	„ 34.5	−79.2†						
630	„ ...	9 23.0	„ 25.5	−02.5†						
631	„ ...	11 06.1	„ 27.7	98.4†						
632	„ ...	7 21.9	„ 25.6	−123.7†						
633	„ ...	9 19.9	„ 05.2	14.7†	66 04.0	69 15.8	−191.8			
634	„ ...	10 47.9	„ 17.1	90.8†	„ 16.0	„ 29.4	−193.4			
635	„ ...	„ 49.7	„ 09.5	100.2†	65 38.1	68 55.0	−196.9			
636	„ ...	9 30.3	8 52.5	37.8†	„ 14.0	„ 20.8	−186.8			
637	„ ...	10 15.4	9 01.9	73.5†	64 51.0	„ 25.4	−214.4			
638	„ ..	8 51.2	8 31.2	20.0†	„ 13.0	67 04.9	−171.9			
639	„ ...	9 59.3	„ 44.2	75.1†	„ 23.0	„ 20.3	−177.3			
640	„ ...	8 15.1	„ 21.4	−06.3†	„ 06.0	66 27.7	−141.7			
641	„ ...	9 52.4	„ 31.8	80.6†	63 29.0	„ 27.0	−178.0			

TABLE 13.

OBSERVED AND CALCULATED VALUES OF FIRST RESIDUALS OF DECLINATION, AND THEIR SECOND RESIDUALS.

PART I

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
1	Sikuka	38.6	43.4	−04.8
2	Usyoro	41.6	46.0	−04.4
3	Higasi-Siraoro	25.6	43.3	−17.7
4	Maoka	59.1	43.3	15.8
5	Toyohara	60.5	41.8	18.7
6	Ōtomari	45.3	41.0	04.3
7	Wakkanai...	57.5	41.0	16.5
8	Monbetu	40.2	34.3	05.9
9	Rumoi	40.8	37.8	03.0
10	Asahikawa	57.0	36.0	21.0
12	Sappero	40.3	36.3	04.0
13	Siranuka	07.1	28.3	−21.2
14	Ikeda	18.3	30.3	−12.0
15	Saruhuto	41.8	33.8	08.0
16	Setana	39.9	37.5	02.4
17	Moyeri	24.9	29.3	−04.4
18	Mori	38.4	35.5	02.9
19	Nohezi	43.5	31.0	12.5
20	Azigasawa	23.7	32.0	−08.3
21	Ōdate	32.3	30.3	02.0
22	Kuzi	13.2	26.8	−13.6
23	Akita	25.5	29.0	−03.5
24	Yokote	27.8	27.0	00.8
25	Mizusawa	28.4	24.8	03.6
26	Yonegasaki	27.9	23.3	04.6
27	Sakata	27.9	26.8	01.1
28	Yamagata	17.9	23.8	−05.9
29	Sendai	27.6	22.3	05.3
30	Niigata	31.6	24.0	07.6
31	Wakamatu	17.4	21.3	−03.9
32	Wazima	21.9	24.3	−02.4
33	Tōkamati	24.6	22.0	02.6
34	Itoigawa	27.5	22.5	05.0

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
36	Ueda	15.4	17.8	—2.4
37	Mito	15.4	15.8	—0.4
38	Matuida	24.6	18.8	5.8
39	Sioya	33.0	20.8	12.2
40	Tyôsi	10.7	12.3	—01.6
41	Hatiôzi	17.1	15.3	01.8
42	Miyazu	19.1	18.0	01.1
43	Iida	15.1	16.3	—01.2
44	Obama	20.9	18.0	02.9
45	Tottori	27.5	17.5	10.0
46	Nagahama	19.6	17.3	02.3
47	Imaiti	14.9	14.8	00.1
48	Kurosaka	18.0	15.5	02.5
50	Kamikamo	15.8	16.0	—00.2
51	Tomida	19.2	15.3	03.9
52	Kakegawa...	11.7	13.5	—01.8
53	Toyohasi	17.2	14.0	03.2
54	Okayama	15.4	14.5	00.9
55	Miyagawa...	14.6	13.3	01.3
56	Hirosima	08.6	10.5	—01.9
57	Sumoto	12.5	12.8	—00.3
58	Yamaguti	07.3	08.5	—01.2
59	Minabe	10.3	11.0	—00.7
60	Katuura	09.2	10.3	—01.1
61	Tokusima	11.0	12.0	—01.0
62	Imaharu	12.6	10.3	02.3
63	Ôsato	08.8	10.0	—01.2
64	Wakamiya	06.9	07.5	—00.6
65	Susaki	08.3	08.0	00.3
66	Izuhara	17.4	03.8	13.6
67	Nakatu	10.0	05.0	05.0
68	Karatu	06.4	01.3	05.1
69	Saheki	00.0	04.3	—04.3
71	Simabara	00.0	00.0	00.0
73	Zaikôzi	01.6	01.3	00.3

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f. — c.)
		′	′	′
74	Hitoyosi	—00.9	—01.3	00.4
75	Usibuka	—04.3	—03.0	—01.3
76	Miyazaki	—01.7	—01.5	—00.2
79	Nisi-no-Omote	—06.5	—07.5	01.0
81	Yûki	22.1	27.3	—05.2
82	Zyôsin	16.9	19.8	—02.9
83	Hokusei	10.0	14.5	—04.5
84	Gisyû	—10.2	—06.0	—04.2
85	Kisen	05.0	04.0	01.0
86	Kizyô	00.2	—01.0	01.2
87	Eikô	05.5	08.8	—03.3
88	Genzan	11.9	08.3	03.6
89	Heizyô	—05.4	—00.3	—05.1
91	Zuikô	—07.3	00.5	—07.8
92	Mukinpo	—09.7	09.0	—18.7
93	Tyûmonzin	09.4	11.0	—01.6
94	Syunsen	08.4	06.3	02.1
95	Zinsen	—07.6	00.5	—08.1
99	Kôkan	—02.2	02.5	—04.7
100	Hokô	07.4	08.0	—00.6
101	Taikyû	09.2	04.8	04.4
102	Zensyû	—01.8	—01.3	—00.5
103	Sinsyû	—10.7	00.8	—11.5
104	Kôsyû	—00.5	—05.5	05.0
105	Huzan	03.4	04.0	—00.6
106	Moppo	—13.0	—09.3	—03.7
107	Kôyô	—09.8	—05.0	—04.8
109	Pu-lan-tien	—23.2	—24.0	00.8
110	Chou-shui-tzu	—22.9	—28.0	05.1
302	Mean of 6 Stations...	—05.2	08.0	—13.2
303	Mean of 23 Stations	—11.5	—14.0	02.5
338		—19.9	—06.5	—13.4
503	Tsingtau	—23.5	—35.0	11.5
623	Sikotan	—06.5	18.0	—24.5

PART II

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
66	Izuhara	17.4	—00.5	17.9
67	Nakatu	10.0	—02.0	12.0
68	Karatu	06.4	—02.8	09.2
69	Saheki	00.0	—04.5	04.5
71	Simabara	00.0	—05.3	05.3
73	Zaikôzi	01.6	—07.3	08.9
74	Hitoyosi	—00.9	—08.0	07.1
75	Usibuka	—04.3	—07.8	03.5
76	Miyazaki	—01.7	—09.5	07.8
79	Nisi-no-Omote	—06.5	—15.5	09.0
83	Hokusei	10.0	11.0	—01.0
84	Gisyû	—10.2	—07.5	—02.7
85	Kisen	05.0	01.0	04.0
86	Kizyô	00.2	—04.0	04.2
87	Eikô	05.5	05.5	00.0
88	Genzan	11.9	06.0	05.9
89	Heizyô	—05.4	—01.0	—04.4
91	Zuikô	—07.3	00.3	—07.6
92	Mukinpo	—09.7	—04.8	—04.9
93	Tyûmonzin	09.4	08.5	00.9
94	Syunsen	08.4	05.0	03.4
95	Zinsen	—07.6	01.0	—08.6
99	Kôkan	—02.2	03.0	—05.2
100	Hokô	07.4	05.5	01.9
101	Taikyû	09.2	03.8	05.4
102	Zensyû	—01.8	00.3	—02.1
103	Sinsyû	—10.7	00.8	—11.5
104	Kôsyû	—00.5	—00.8	00.3
105	Huzan	03.4	02.3	01.1
106	Moppo	—13.0	—02.0	—11.0
107	Kôyô	—09.8	—01.8	—08.0
108	Hônan	—33.3	—01.8	—31.5
109	Pu-lan-tien	—23.2	—17.5	—05.7

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
110	Chou-shui-tzu	−22.9	−17.8	−05.1
115	Tansui	00.4	−05.3	05.7
116	Taihoku	03.4	−05.8	09.2
117	Rokkô	−09.8	−00.8	−09.0
118	Kwarenkô...	−18.9	−06.8	−12.1
120	Tainan	−01.4	00.3	−01.7
121	Pinan...	−11.4	−06.0	−05.4
122	Taihanroku	−04.5	−03.8	−00.7
201	Newchwang	−24.9	−19.0	−05.9
203	Tientsin	−30.9	−34.3	03.4
205	Tsinan	−13.5	−24.0	10.5
206	Yangchow Resid.	−08.7	−07.8	−00.9
207	„ Hospital	−08.6	−07.5	−01.1
208	Chinkiang Resid.	01.4	−07.5	08.9
209	„ Vict. Park	00.4	−07.3	07.7
211	Woosung	−13.9	−03.8	−10.1
212	Hangchow	−03.6	−01.8	−01.8
215	Wenchow	−12.1	−02.3	−09.8
216	Foochow	04.7	03.3	01.4
217	Amoy...	04.8	10.0	−05.2
218	Swatow	21.0	19.3	01.7
301		−61.4	−70.0	08.6
302		−05.2	−05.0	−00.2
303		−11.5	−15.0	03.5
304	Peking	−37.8	−43.8	06.0
305		−44.4	−38.8	−05.6
308	Suchow An	−03.9	−12.0	08.1
311	Nanchang...	24.8	08.0	16.8
503	Tsingtau	−23.5	−15.0	−08.5
504	Lukiapang	−03.9	−03.5	−00.4
506	Hongkong...	43.8	34.9	08.9

PART III

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f. − c.)
		′	′	′
1	Sikuka	38.6	54.2	−15.6
2	Usyoro	41.6	59.8	−18.2
3	Higasi-Siraoro	25.6	48.5	−22.9
4	Maoka	59.1	46.1	13.0
5	Toyohara	60.5	41.0	19.5
6	Ôtomari	45.3	38.6	06.7
7	Wakkanai...	57.5	37.5	20.0
8	Monbetu	40.2	20.3	19.9
11	Sibetu	28.4	06.5	21.9
17	Moyori	24.9	08.6	16.3
26	Yonegasaki	27.9	−00.6	28.5
36	Ueda	15.4	−07.3	22.7
37	Mito	15.4	−08.5	23.9
40	Tyôsi	10.7	−13.1	23.8
59	Minabe	10.3	00.4	09.9
60	Katuura	09.2	−03.1	12.3
63	Ôsato	08.8	04.3	04.5
64	Wakamiya	06.9	11.6	−04.7
65	Susaki	08.3	07.4	00.9
67	Nakatu	10.0	18.8	−08.8
68	Karatu	06.4	24.0	−17.6
69	Saheki	00.0	11.2	−11.2
71	Simabara	00.0	17.5	−17.5
73	Zaikôzi	01.6	09.1	−07.5
74	Hitoyosi	−00.9	12.0	−12.9
75	Usibuka	−04.3	15.3	−19.6
76	Miyazaki	−01.7	07.1	−08.8
79	Nisi-no-Omote	−06.5	01.9	−08.4
80	Naze	−11.7	−05.7	−06.0
111	Nago	−18.7	−10.1	−08.6
112	Naha	−29.2	−11.1	−18.1
113	Miyako	−19.0	−10.7	−08.3
114	Isigaki	−12.6	−09.3	−03.3

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f −c.)
		′	′	′
115	Tansui	00.4	07.1	−06.7
116	Taihoku	03.4	05.7	−02.3
117	Rokkô	−09.8	03.4	−13.2
118	Kwarenkô	−18.9	−01.8	−17.1
120	Tainan	−01.4	−02.8	01.4
121	Pinan	−11.4	−08.1	−03.3
122	Taihanroku	−04.5	−11.8	07.3
123	Okumura	−05.4	−47.0	41.6
124	Ômura	−05.3	−47.0	41.7
126	Higasiminato	−02.5	−47.9	45.4
127	Kitamura	−04.5	−47.9	43.4
128	Okimura	−21.9	−48.0	26.1
129	Minamizaki	−16.6	−48.1	31.5
130	Pagan	−50.7	−55.9	05.2
131	Saipan	−79.1	−53.1	−26.0
132	"	−64.2	−53.0	−11.2
133	Yap	−54.9	−60.7	05.8
134	Palau	−47.5	−66.7	19.2
135	"	−37.4	−66.6	29.2
136	"	−57.1	−66.7	09.6
137	Olol	−76.1	−25.2	−50.9
139	Wolea	−61.7	−41.6	−20.1
141	Lossop	−49.4	−04.6	−44.8
142	Ponape	−38.3	23.5	−61.8
143	Kusaie	57.3	63.2	−05.9
144	Mortlock	−48.0	08.6	−56.6
145	Brown	−27.0	16.7	−43.7
146	Rongelab	24.8	42.3	−17.5
147	Jaluit	122.7	104.3	18.4
213	Putu	11.2	38.2	−27.0
214	Ningpo	01.3	41.7	−40.4
215	Wenchow	−12.1	31.8	−43.9
216	Foochow	04.7	23.0	−18.3
217	Amoy	04.8	16.6	−11.8
218	Swatow	21.0	14.6	06.4

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
316	Guam, Orote Point...	−72.2	−52.8	−19.4
317	" Cabras Island	−66.3	−52.5	−13.8
318	" Sumay	−71.9	−52.5	−19.4
319	Maraki Island	217.7	173.8	43.9
320	Apaiang	218.8	173.1	45.7
321	Tarawa	213.1	177.9	35.2
326		14.1	−71.2	85.3
628		−34.4	−52.7	18.3
330		−51.9	−62.6	10.7
332		−45.0	−64.2	19.2
334		−01.2	−33.6	32.4
336		−35.4	−20.8	−14.6
338		−19.9	−26.0	06.1
340		−20.2	−44.5	24.3
341		−58.4	−57.0	−01.4
342		−75.2	−61.8	−13.4
344		−38.5	−38.2	−00.3
347		58.5	24.0	34.5
351		−168.3	−91.7	−76.6
353		−96.7	−77.4	−19.3
355		−83.5	−67.9	−15.6
357		−70.4	−72.2	01.8
358		−52.0	−66.5	14.5
360		−44.8	−47.1	02.3
365		−35.5	−15.8	−19.7
368		−26.1	10.5	−36.6
371		−02.4	39.8	−42.2
376		23.3	78.0	−54.7
378		78.9	39.2	39.7
380		−38.5	−06.8	−31.7
382		−79.9	−34.7	−45.2
383		−84.0	−41.8	−42.2
385		−75.9	−46.4	−29.5
386		−67.6	−52.6	−15.0
388		−64.5	−57.3	−07.2

Station		Declination		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
389		—51.2	—55.9	04.7
391		—21.2	—46.2	25.0
394		—20.4	—48.7	28.3
396		—56.2	—54.2	—02.0
398		—69.6	—64.1	—05.5
399		—81.9	—78.9	—03.0
401		—87.9	—94.2	06.3
5c8	Antipolo	12.0	—53.1	65.1

TABLE 14.

OBSERVED AND CALCULATED VALUES OF FIRST RESIDUALS OF DIP, AND THEIR SECOND RESIDUALS.

PART I

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
1	Sikuka	−146.0	−162.3	16.3
2	Usyoro	−153.5	−156.2	02.7
3	Higasi-Siraoro	−135.6	−138.1	02.5
4	Maoka	−131.2	−124.4	−06.8
5	Toyohara	−125.1	−122.6	−02.5
6	Ôtomari	−120.9	−117.4	−03.5
7	Wakkanai	−110.3	−97.7	−12.6
8	Monbetu	−93.9	−80.8	−13.1
9	Rumoi	−83.8	−74.5	−09.3
10	Asahikawa	−81.0	−71.4	−09.6
11	Sibetu	−62.4	−71.8	09.4
12	Sapporo	−73.5	−61.4	−12.1
13	Siranuka	−63.4	−60.4	−03.0
14	Ikeda	−69.3	−59.7	−09.6
15	Saruhuto	−52.0	−53.3	01.3
16	Setana	−85.9	−53.2	−32.7
17	Moyori	−71.8	−50.4	−21.4
18	Mori	−64.9	−47.7	−17.2
19	Nohezi	−52.6	−30.4	−22.2
20	Azigasawa	−43.2	−29.3	−13.9
21	Ôdate	−44.1	−22.6	−21.5
22	Kuzi	−26.3	−21.5	−04.8
23	Akita	−33.6	−15.3	−18.3
24	Yokote	−33.7	−10.5	−23.2
25	Mizusawa	−32.9	−08.1	−24.8
26	Yonegasaki	−10.1	−06.6	−03.5
27	Sakata	−22.4	−05.4	−17.0
28	Yamagata	−16.6	02.7	−19.3
29	Sendai	−10.6	02.8	−13.4
30	Niigata	−06.8	06.5	−13.3
31	Wakamatu	04.0	11.8	−07.8
32	Wazima	−09.8	11.0	−20.8
33	Tôkamati	11.1	15.5	−04.4

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f. – c.)
		′	′	′
34	Itoigawa	06.0	16.1	–10.1
35	Kuroiso	–00.2	17.8	–18.0
36	Ueda	03.9	18.3	–14.4
37	Mito	09.0	24.2	–15.2
38	Matuida	02.2	24.9	–22.8
39	Sioya	22.4	22.9	–00.5
40	Tyôsi	–05.5	31.0	–36.5
41	Hatiôzi	05.2	32.1	–26.9
42	Miyazu	18.9	29.9	–11.0
43	Iida	15.1	33.1	–18.0
44	Obama	19.4	31.1	–11.7
45	Tottori	28.2	28.5	–00.3
46	Nagahama	24.0	33.2	–09.2
47	Imaiti...	42.9	26.7	16.2
48	Kurosaka	30.5	30.0	00.5
49	Yunotu	64.9	28.6	36.3
50	Kamikamo	27.8	36.0	–08.2
51	Tomida	27.7	37.6	–09.9
52	Kakegawa...	26.2	41.0	–14.8
53	Toyohasi	36.5	40.8	–04.3
54	Okayama	29.6	37.0	–07.4
55	Miyagawa	35.5	42.7	–07.2
56	Hirosima	31.9	36.7	–04.8
57	Sumoto	34.3	42.2	–07.9
58	Yamaguti	35.4	36.2	–00.8
59	Minabe	43.2	48.8	–05.6
60	Katuura	47.5	50.9	–03.4
61	Tokusima	34.4	44.5	–10.1
62	Imaharu	38.9	41.4	–02.5
63	Ôsato	35.5	47.9	–12.4
64	Wakamiya	42.3	46.0	–03.7
65	Susaki	49.1	49.0	00.1
66	Izuhara	38.8	28.0	10.8
67	Nakatu	51.5	41.4	10.1
68	Karatu	48.9	39.0	09.9

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f.−c.)
		′	′	′
69	Saheki	69.7	50.0	19.7
70	Miyazi	68.3	48.1	20.2
71	Simabara	51.2	47.3	03.9
73	Zaikôzi	70.7	54.7	16.0
74	Hitoyosi	64.4	54.1	10.3
76	Miyazaki	77.2	58.8	18.4
77	Nisi-Itiki	76.3	57.8	18.5
78	Makurazaki	94.5	61.7	32.8
79	Nisi-no-Omote	84.6	68.4	16.2
80	Naze	109.0	83.6	25.4
81	Yûki	−91.7	−76.3	−15.4
82	Zyôsin	−53.7	−56.3	02.6
83	Hokusei	−59.5	−54.0	−05.5
84	Gisyû	−72.3	−76.0	03.7
85	Kisen	−70.6	−64.8	−05.8
86	Kizyô	−78.5	−67.8	−10.7
87	Eikô	−48.9	−49.5	00.6
88	Genzan	−48.7	−43.0	−05.7
89	Heizyô	−54.7	−50.4	−04.3
90	Tyôzen	−36.1	−33.2	−02.9
91	Zuikô	−47.6	−39.8	−07.8
92	Mukinpo	−47.9	−44.2	−03.7
93	Tyûmonzin	−24.6	−18.6	−06.0
94	Syunsen	−23.0	−23.7	00.7
95	Zinsen	−25.5	−24.1	−01.4
96	Tikuhen	−06.5	−05.4	−01.1
97	Tyûsyû	−25.4	−10.5	−14.9
98	Gôsen	−09.8	−10.7	00.9
99	Kôkan	02.9	−00.3	03.2
100	Hokô	14.1	07.5	06.6
101	Taikyû	01.4	06.5	−05.1
102	Zensyû	02.5	00.1	02.4
103	Sinsyû	18.0	12.2	05.8
104	Kôsyû	14.6	07.3	07.3
105	Huzan	16.3	17.4	−01.1

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f. – c.)
		′	′	′
106	Moppo	13.7	09.1	04.6
107	Kôyô	50.3	15.5	34.8
108	Hônan	26.9	16.2	10.7
109	Pu-lan-tien	–83.0	–81.3	–01.7
110	Chou-Shui-tzu	–84.0	–77.5	–06.5
111	Nago	111.4	91.5	19.9
112	Naha	113.7	93.0	20.7
113	Miyako	110.2	93.0	17.2
114	Isigaki	101.9	90.9	11.0
115	Tansui	91.1	71.8	19.3
116	Taihoku	76.6	73.2	03.4
117	Rokkô	63.1	73.4	–10.3
118	Kwarenkô...	87.3	80.4	06.9
119	Hôkotô	56.3	71.0	–14.7
120	Tainan	72.2	78.2	–06.0
121	Pinan	84.8	84.9	–00.1
122	Taihanroku	79.2	86.9	–07.7
123	Okumura	79.1	95.4	–16.3
124	Ômura	113.8	95.5	18.3
125	Ôgiura	114.9	95.6	19.3
126	Higasiminato	130.0	97.5	32.5
127	Kitamura	117.1	97.6	19.5
128	Okimura	123.1	97.8	25.3
129	Minamizaki	143.0	97.8	45.2
130	Pagan...	94.1	100.7	–06.6
131	Saipan	94.4	95.8	–01.4
132	"	98.5	95.4	03.1
133	Yap	68.2	106.1	–37.9
134	Palau	91.4	103.7	–12.3
135	"	89.5	103.6	–14.1
136	"	83.4	103.6	–20.2
137	Olol	71.6	36.9	34.7
139	Wolea...	54.1	67.3	–13.2
201	New-chwang	–101.0	–100.6	–00.4
202	Shanhaikwan	–124.7	–107.7	–17.0

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
203	Tientsin	−132.0	−116.6	−15.4
204	Chefoo	−66.7	−57.8	−08.9
205	Tsinan	−105.4	−81.5	−23.9
206	Yangchow Residence	02.2	−06.6	08.8
207	„ Hospital...	01.9	−06.6	08.5
208	Chinkiang Residence	−02.1	−04.9	02.8
209	„ Vict. Park	03.8	−04.7	08.5
210	Nanking	−02.4	−07.8	05.4
211	Woosung	29.4	18.7	10.7
212	Hangchow	25.6	20.5	05.1
213	Putu	77.5	38.1	39.4
214	Ningpo	49.1	34.1	15.0
215	Wenchow	73.6	45.3	28.3
216	Foochow	69.6	52.6	17.0
217	Amoy...	74.6	55.7	18.9
218	Swatow	43.2	52.9	−09.7
301	Mean of 3 Stations...	−314.5	−280.5	−34.0
302	„ 6 „	−192.5	−170.6	−21.9
303	„ 23 „	−116.6	−101.8	−14.8
305	„ 22 „	−153.3	−127.8	−25.5
308	Suchow. An.	−56.8	−41.6	−15.2
309	Wuhu...	−01.9	−03.5	01.6
310	Soochow	36.1	13.6	22.5
311	Nanchang...	05.5	03.8	01.7
312	Mean of 30 Stations	38.3	35.0	03.3
316	Guam. Orote Point...	70.0	96.6	−26.5
317	„ Cabras Island	84.1	95.8	−11.7
318	„ Sumay	86.8	95.8	−09.0
327	Mean of 4 Stations...	83.3	57.0	26.3
329	„ 2 „	72.5	69.3	03.2
331	„ 3 „	100.3	114.2	−13.8
333	„ 3 „	125.9	128.9	−03.0
335	„ 16 „	83.5	101.4	−17.9
337	„ 4 „	133.4	102.1	31.3
339	„ 6 „	82.5	67.4	15.1

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f. – c.)
		′	′	′
387	Mean of 4 Stations...	104.9	106.3	–01.4
390	" 3 "	95.6	99.7	–04.1
392	" 3 "	53.6	68.0	–14.4
503	Tsingtau (China)	–49.0	– 46.0	–03.0
504	Lukiapang (China)...	25.6	16.4	09.2
508	Antipolo (Luzon)	84.1	108.4	–24.3
623	Sikotan	–28.4	–77.2	48.8
624	"	–98.9	–75.2	–23.7
625	"	–62.0	–73.2	11.2
633	Karahuto	–191.8	–232.3	40.5
634	"	–193.4	–232.5	39.1
635	"	–196.9	–221.1	24.2
636	"	–186.8	–214.6	27.8
637	"	–214.4	–211.3	–03.1
638	"	–171.9	–193.4	21.5
639	"	–177.3	–193.2	15.9
640	"	–141.7	–183.2	41.5
641	"	–178.0	–177.9	00.1

PART II

		′	′	′
1	Sikuka	–146.0	–149.7	03.7
2	Usyoro	–153.5	–147.7	–05.8
3	Higasi-Siraoro	–135.6	–128.7	–06.9
4	Maoka	–131.2	–117.5	–13.7
5	Toyohara	–125.1	–113.5	–11.6
6	Ôtomari	–120.9	–108.3	–12.6
7	Wakkanai...	–110.3	–94.1	–16.2
8	Monbetu	–93.9	–71.9	–22.0
9	Rumoi	–83.8	–73.1	–10.7
10	Asahikawa	–81.0	–67.3	–13.7
11	Sibetu...	–62.4	–56.1	–06.3
12	Sapporo	–73.5	–62.5	–11.0
13	Siranuka	–63.4	–50.0	–13.4

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
14	Ikeda...	−69.3	−52.2	−17.1
15	Saruhuto	−52.0	−52.4	00.4
17	Moyori	−71.8	−44.3	−27.5
18	Mori	−64.9	−53.5	−11.4
19	Nohezi	−52.6	−36.1	−16.5
20	Azigasawa...	−43.2	−39.1	−04.1
21	Ôdate	−44.1	−31.8	−12.3
22	Kuzi	−26.3	−25.4	−00.9
23	Akita	−33.6	−27.5	−06.1
24	Yokote	−33.7	−21.3	−12.4
25	Mizusawa	−32.9	−16.8	−16.1
26	Yonegasaki	−10.1	−13.1	03.0
28	Yamagata	−16.6	−11.4	−05.2
29	Sendai	−10.6	−08.8	−01.8
35	Kuroiso	−00.2	−00.4	00.2
36	Ueda	03.9	03.6	00.3
37	Mito	09.0	06.8	02.2
40	Tyôsi	−05.5	14.0	−19.5
123	Okumura	79.1	65.7	13.4
124	Ômura	113.8	65.7	48.1
125	Ôgiura	114.9	65.8	49.1
126	Higasiminato	130.0	66.4	63.6
127	Kitamura	117.1	66.4	50.7
128	Okimura	123.1	66.5	56.5
129	Minamizaki	143.0	66.7	76.2
130	Pagan	94.1	74.5	19.6
131	Saipan	94.4	60.8	33.6
132	"	98.5	60.5	38.0
137	Olol	71.6	21.8	49.8
138	Truk	−108.6	15.0	−123.6
139	Wolea...	54.1	−11.9	66.0
140	Truk	−29.0	14.8	−43.8
141	Lossop	−13.9	11.6	−25.5
142	Ponape	−16.5	18.5	−35.0
143	Kusaie	45.4	02.4	43.0

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
144	Mortlock	08.7	−04.6	13.3
145	Brown	00.8	62.5	−61.7
146	Rongelab	27.7	56.6	−28.9
147	Jaluit	−17.6	00.6	−18.2
316	Guam, Oroté Point...	70.0	46.5	23.5
317	„ Cabras Island	84.1	45.7	38.4
318	„ Sumay	86.8	45.5	41.3
319	Maraki Island	−102.6	−58.5	−44.1
320	Apaiang	−57.8	−59.9	02.1
321	Tarawa	−85.4	−66.8	−18.6
339		82.5	61.1	21.4
343		43.3	90.8	−47.5
345		95.3	91.9	03.4
346		113.6	82.4	31.2
348		107.6	55.0	52.6
350		−88.3	−262.9	174.6
352		−96.5	−152.6	56.1
354		−94.0	−62.9	−31.1
356		−49.3	22.4	−71.7
359		08.7	64.0	−55.4
361		28.7	83.8	−55.1
362		56.8	96.5	−39.7
363		107.9	102.0	05.9
364		84.3	98.4	−14.1
366		70.4	99.4	−29.0
367		67.3	86.6	−19.3
369		74.1	75.4	−01.3
370		03.0	59.3	−56.3
372		24.4	35.8	−11.4
373		00.8	09.4	−08.6
374		−09.1	−15.5	06.4
375		−44.3	−29.1	−15.2
377		−33.5	−54.9	21.4
379		121.4	64.8	56.6
381		64.9	106.1	−41.2

Station		Dip		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		′	′	′
384		89.5	79.1	10.4
387		104.9	63.8	41.1
390		95.6	74.9	20.7
392		53.6	59.2	−05.6
393		−06.2	38.3	−44.5
395		−73.8	−10.2	−63.6
397		−102.1	−72.8	−29.3
400		−94.0	−112.9	18.9
623	Sikotan	−28.4	−53.5	25.1
624	"	−98.9	−52.5	−46.4
625	"	−62.0	−52.0	−10.0
633	Karahuto	−191.8	−216.9	25.1
634	"	−193.4	−220.0	26.6
635	"	−196.9	−209.5	12.6
636	"	−186.8	−200.0	13.2
637	"	−214.4	−200.8	−13.6
638	"	−171.9	−178.1	06.2
639	"	−177.3	−182.3	05.2
640	"	−141.7	−167.7	26.0
641	"	−178.0	−167.8	−10.2

TABLE 15.

OBSERVED AND CALCULATED VALUES OF FIRST RESIDUALS OF HORIZONTAL INTENSITY, AND THEIR SECOND RESIDUALS.

PART I

Station		Horizontal Intensity		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
1	Sikuka	−165 γ	−164 γ	−1 γ
2	Usyoro	−75	−161	86
3	Higasi-Siraoro	−114	−104	−10
4	Maoka	34	−72	106
5	Toyohara	46	−66	112
6	Ôtomari	39	−54	93
7	Wakkanai...	142	−13	155
8	Monbetu	45	0	45
9	Rumoi	107	27	80
10	Asahikawa	−42	23	−65
11	Sibetu	−325	−33	−292
12	Sapporo	−109	47	−156
13	Siranuka	−77	−3	−74
14	Ikeda	−86	14	100
15	Saruhuto	−126	45	−171
16	Setana	272	71	201
17	Moyori	35	18	17
18	Mori	103	71	32
19	Nohezi	42	72	−30
20	Azigasawa	68	89	−21
21	Ôdate	4	86	−82
22	Kuzi	129	55	74
23	Akita	185	95	90
24	Yokote	270	83	187
25	Mizusawa	60	66	−6
26	Yonegasaki	−225	48	−273
27	Sakata	151	99	52
28	Yamagata	137	80	57
29	Sendai	−126	63	−189
30	Niigata	44	113	−69
31	Wakamatu	−81	82	−163
32	Wazima	198	155	43
33	Tôkamati	91	113	−22

Station		Horizontal Intensity		
No.	Name	First Residual	Calculated	Second Residual (f. – c.)
		γ	γ	γ
34	Itoigawa	2	135	−133
36	Ueda	−33	39	−72
37	Mito	−41	39	−80
38	Matuida	107	100	7
39	Sioya	77	163	−86
40	Tyôsi	187	4	183
41	Hatiôzi	37	66	−29
42	Miyazu	215	178	37
43	Iida	37	116	−79
44	Obama	232	168	64
45	Tottori	208	190	18
46	Nagahama	145	156	−11
47	Imaiti...	62	201	−139
48	Kurosaka	226	199	27
50	Kamikamo	196	165	31
51	Tomida	104	141	−37
52	Kakegawa...	65	94	−29
53	Toyohasi	32	115	−83
54	Okayama	251	193	58
55	Miyagawa...	92	132	−40
56	Hirosima	301	208	93
57	Sumoto	207	174	33
58	Yamaguti	287	213	74
59	Minabe	129	156	−27
60	Katuura	106	136	−30
61	Tokusima	182	178	4
62	Imaharu	219	202	17
63	Ôsato	142	178	−36
64	Wakamiya	182	206	−24
65	Susaki	152	194	−42
66	Izuhara	187	197	−10
67	Nakatu	207	216	−9
68	Karatu	147	218	−71
69	Saheki	106	211	−105
71	Simabara	69	221	−152

TABLE 15

Station		Horizontal Intensity		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		γ	γ	γ
73	Zaikôzi	201	210	−9
74	Hitoyosi	191	118	73
75	Usibuka	215	223	−8
76	Miyazaki	225	209	16
77	Nisi-Itiki	38	220	−182
79	Nisi-no-Omote	192	203	−11
80	Naze	144	181	−37
81	Yûki	131	−122	253
82	Zyôsin	26	−66	92
83	Hokusei	23	−78	101
84	Gisyû	−421	−302	−119
85	Kisen	−119	−189	70
86	Kizyô	−158	−233	75
87	Eikô	−100	−86	−14
88	Genzan	46	−51	97
89	Heizyô	−6	−130	124
90	Tyôzen	49	7	42
91	Zuikô	47	−69	116
92	Mukinpo	−80	−125	45
93	Tyûmonzin	119	74	45
94	Syunsen	112	34	78
95	Zinsen	55	11	44
96	Tikuhen	113	125	−12
97	Tyûsyû	41	87	−46
98	Gôsen	73	61	12
99	Kôkan	117	122	−5
100	Hokô	73	160	−87
101	Taikyû	178	150	28
102	Zensyû	89	111	−22
103	Sinsyû	126	160	−34
104	Kôsyû	13	131	−118
105	Huzan	347	181	166
106	Moppo	125	129	−4
108	Hônan	44	161	−117
109	Pu-lan-tien	−571	−417	−154

Station		Horizontal Intensity		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		γ	γ	γ
110	Chou-shui-tzu	−432	−407	−25
111	Nago	174	166	8
112	Naha	214	117	97
113	Miyako	112	168	−56
114	Isigaki	127	172	−45
117	Rokkô	−131	180	−311
118	Kwarenkô	0	183	−183
119	Hôkotô	−84	170	−254
120	Tainan	−13	168	−181
121	Pinan	18	162	−144
122	Taihanroku	−44	146	−190
123	Okumura	−601	−676	75
124	Ômura	−685	−675	−10
125	Ôgiura	−414	−677	263
126	Higasiminato	−579	−712	133
127	Kitamura	−927	−712	−215
128	Okimura	−398	−719	321
129	Minamizaki	−572	−723	151
201	Newchwang	−649	−536	−113
202	Shanhaikwan	−540	−667	127
203	Tientsin	−873	−825	−48
204	Chefoo	−280	−281	1
205	Tsinan	−523	−576	53
206	Yangchow Resid.	−227	−57	−170
207	" Hospital...	−197	−57	−140
208	Chinkiang Resid.	−109	−49	−60
209	" Vict. Park	−67	−48	−19
210	Nanking	−299	−76	−223
211	Woosung	68	90	−22
212	Hangchow	−42	76	−118
214	Ningpo	−48	142	−190
215	Wenchow	−284	160	−444
216	Foochow	−79	159	−238
217	Amoy...	−260	147	−407
218	Swatow	−215	123	−338

Station		Horizontal Intensity		
No.	Name	First Residual	Calculated	Second Residual (f.—c.)
		γ	γ	γ
503	Tsingtau	−371	−253	−118
504	Lukiapang	18	74	−56

PART II

		γ	γ	γ
80	Naze	144	398	−254
111	Nago	174	238	−64
112	Naha	214	200	14
113	Miyako	112	76	36
114	Isigaki	127	24	103
123	Okumura	−601	−634	33
124	Ōmura	−685	−633	−52
125	Ōgiura	−414	−634	220
126	Higasiminato	−579	−641	62
127	Kitamura	−927	−642	−285
128	Okimura	−398	−645	247
129	Minamizaki	−572	−647	75
130	Pagan	−1014	−765	−249
131	Saipan	−486	−572	86
132	"	−504	−568	64
133	Yap	10	−286	296
134	Palau	−212	−383	171
135	"	−819	−381	−438
136	"	−298	−384	86
137	Olol	114	173	−59
139	Wolea...	158	169	−11
140	Truk	764	408	356
141	Lossop	179	506	−327
142	Ponape	778	569	209
143	Kusaie	533	910	−377
144	Mortlock	768	828	−60
145	Brown	−534	−537	3
146	Rongelab	−1063	−734	−329
147	Jaluit	1062	612	450

TABLE 16.

VALUES OF DECLINATION
ON THE SIBERIAN COAST ADOPTED
FROM THE RUSSIAN CHARTS.

St. No.	Epoch	Sec. Var.	Corr. red. to 1923	Decl. (obs.)		Decl. (red)	
		′	′	°	′	°	′
701	1910	3.23	41.99	7	41.	8	23.
702	„	3.15	40.95	7	28.	8	09.
703	„	3.63	47.19	8	08.	8	55.
704	„	3.75	48.75	8	04.	8	53.
705	1914	3.86	34.74	7	28.	8	03.
706	„	4.20	37.80	8	44.8	9	22.6
707	„	4.27	38.43	9	04.	9	42.
708	1916	5.0	35.00	12	16.	12	51.
709	„	5.08	35.56	12	45.8	13	21.4
710	„	5.13	35.91	11	06.8	11	42.7
711	„	5.17	36.19	10	36.4	11	12.6
712	„	5.24	36.68	11	25.9	12	02.6
713	„	5.29	37.03	9	02.6	9	39.6
714	„	5.35	37.45	10	49.	11	26.
715	„	5.53	38.71	10	59.8	11	38.5
716	1911	5.56	66.72	9	45.	10	52.
717	1912	5.53	60.83	7	39.	8	40.
718	„	5.46	60.06	6	58.	7	58.
719	„	5.38	59.18	8	37.	9	36.
720	„	5.30	58.30	7	22.	8	20.
721	1875	5.41	259.68	4	43.	9	03.
722	1913	5.33	53.3	7	36.	8	29.
723	„	5.25	52.50	7	09.	8	02.
724	„	5.33	53.3	7	08.	8	01.
725	„	5.18	51.8	6	31.	7	23.
726	„	5.23	52.3	5	54.	6	46.
727	„	5.18	51.8	7	22.	8	14.
728	1908	5.25	78.75	6	16.	7	35.
729	„	5.28	79.20	5	43.	7	02.
730	1912	5.28	58.08	6	19.2	7	17.3
731	1913	5.15	51.5	5	26.	6	18.

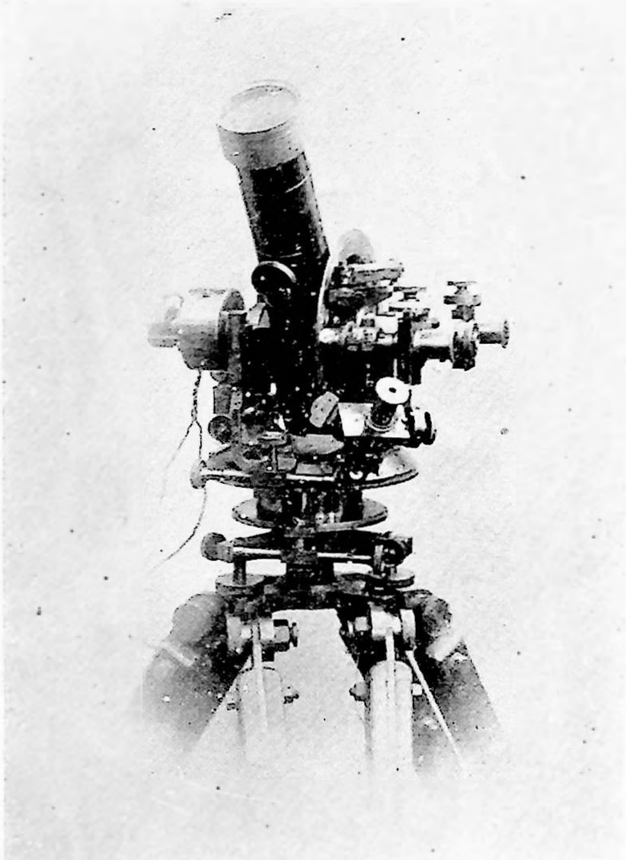


Fig. 1. Magnetometer-theodolite for Astronomical Observation.

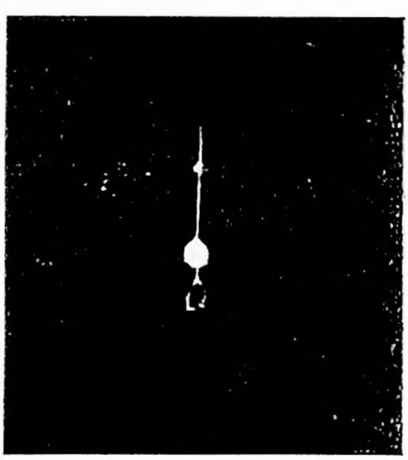


Fig. 2. Hanging Magnet.

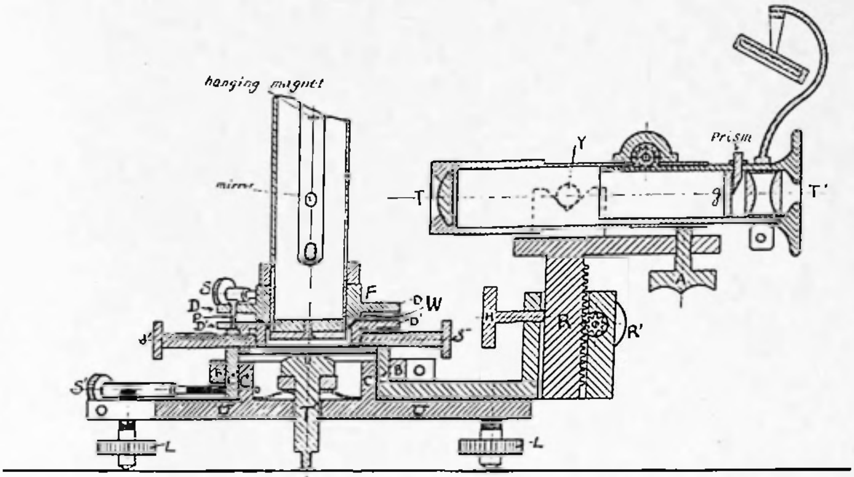


Fig 3. Section of Magnetometer Stand. (½ Natural size).

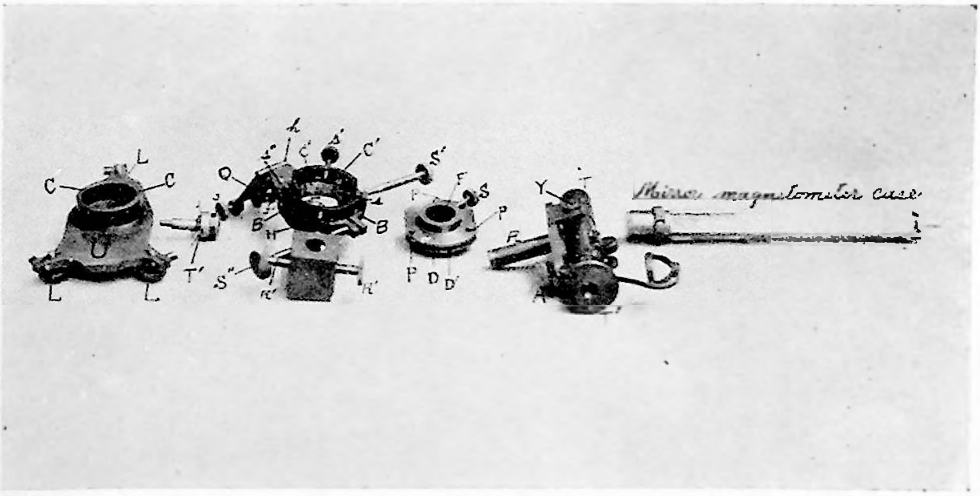


Fig. 4. Magnetometer Stand.

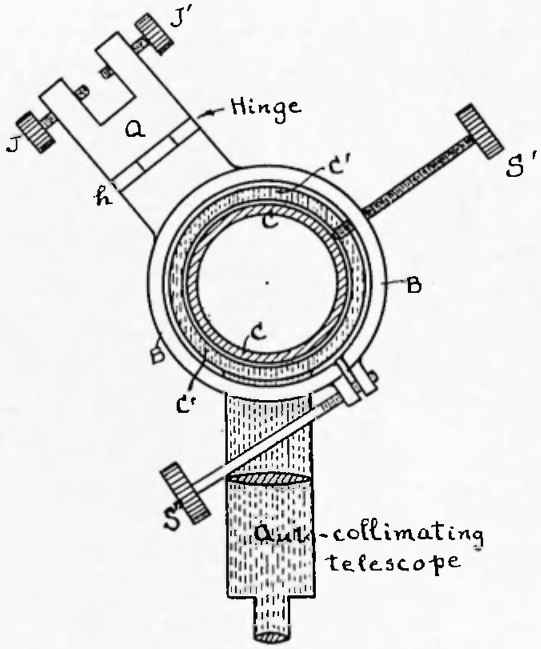


Fig. 5. Diagram of Magnetometer Stand.

Fig. 6. Magnetometer.
(Auto-collimating telescope being fixed to top plate of theodolite).

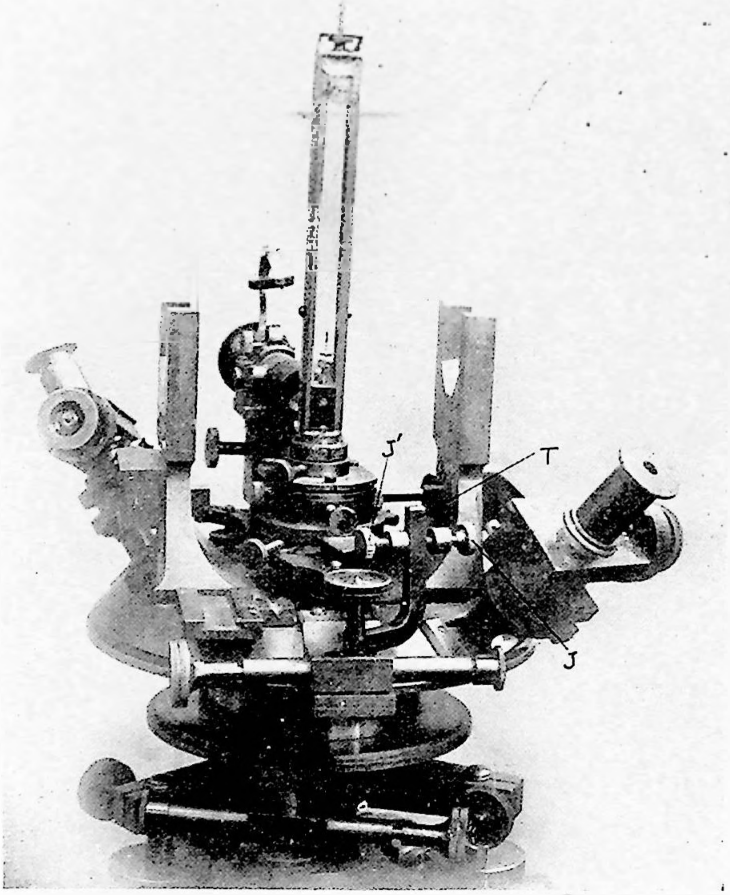


Fig. 7. Magnetometer.
(Auto-collimating telescope being fixed to horizontal circle of theodolite).

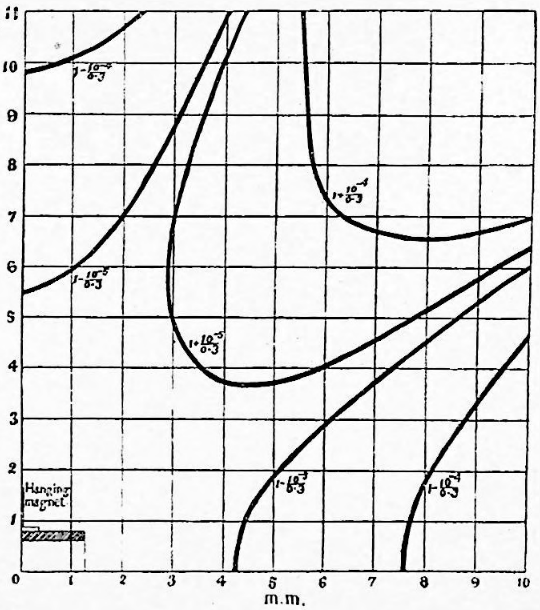


Fig. 8. Diagram of Axial Component.

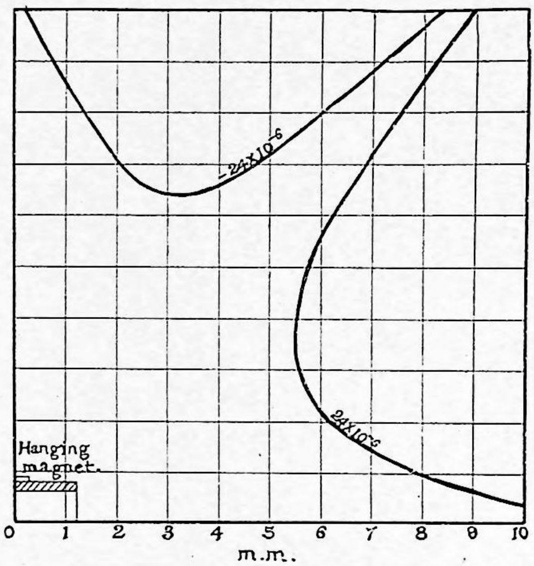


Fig. 9. Diagram of Transversal Component.

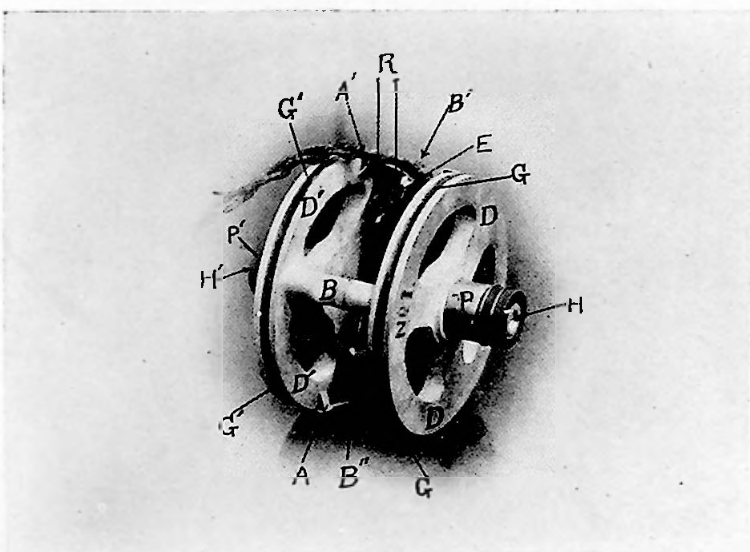


Fig. 10. Helmholtz's Coil.

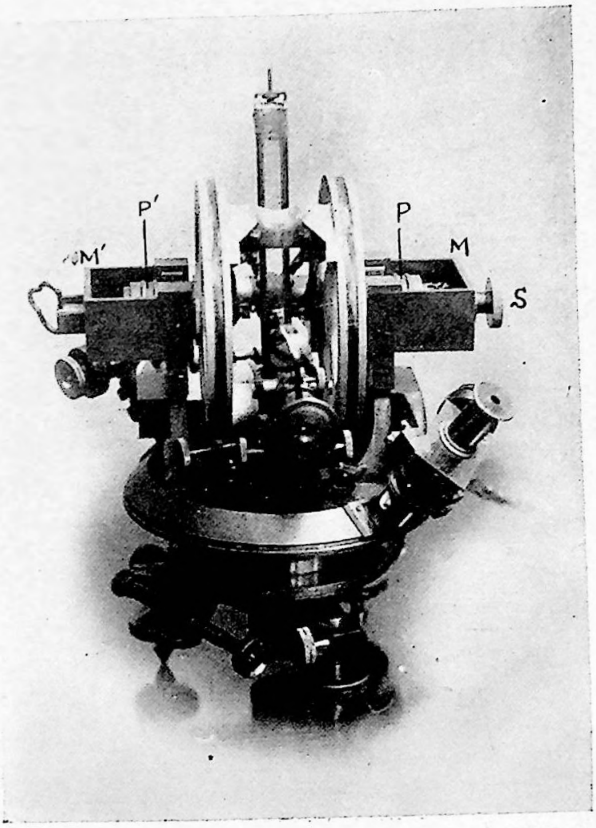


Fig. 11. Coil on Theodolite.

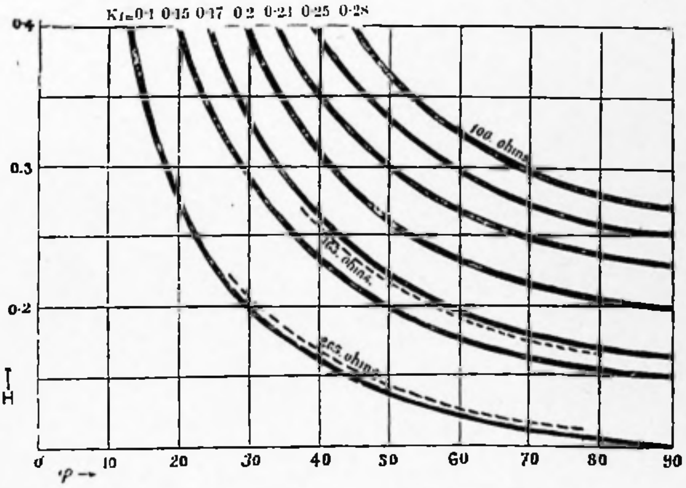


Fig. 12. Diagram of H and Deflection.

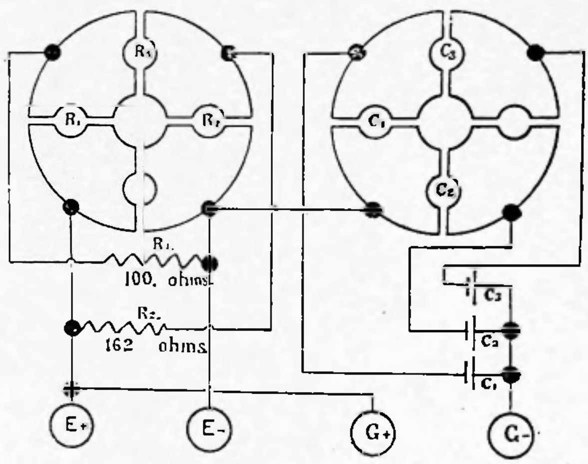


Fig. 13. Connection Diagram of Standard of Current.

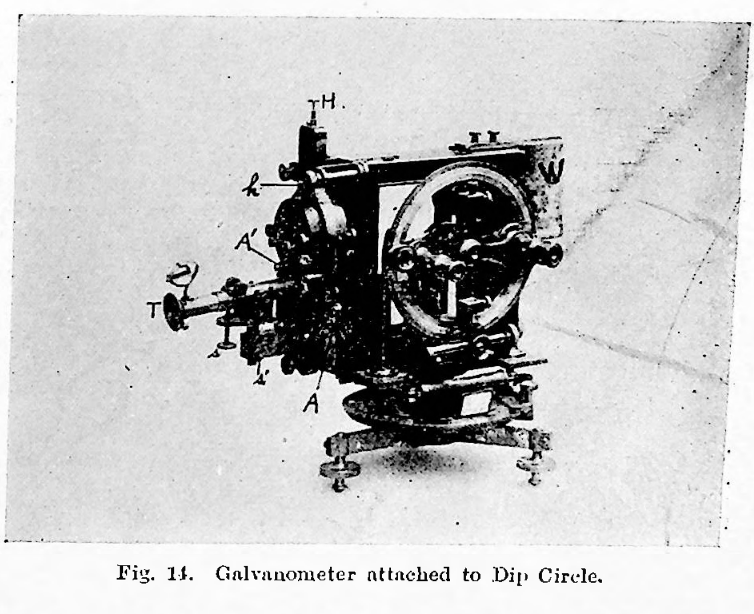


Fig. 14. Galvanometer attached to Dip Circle.

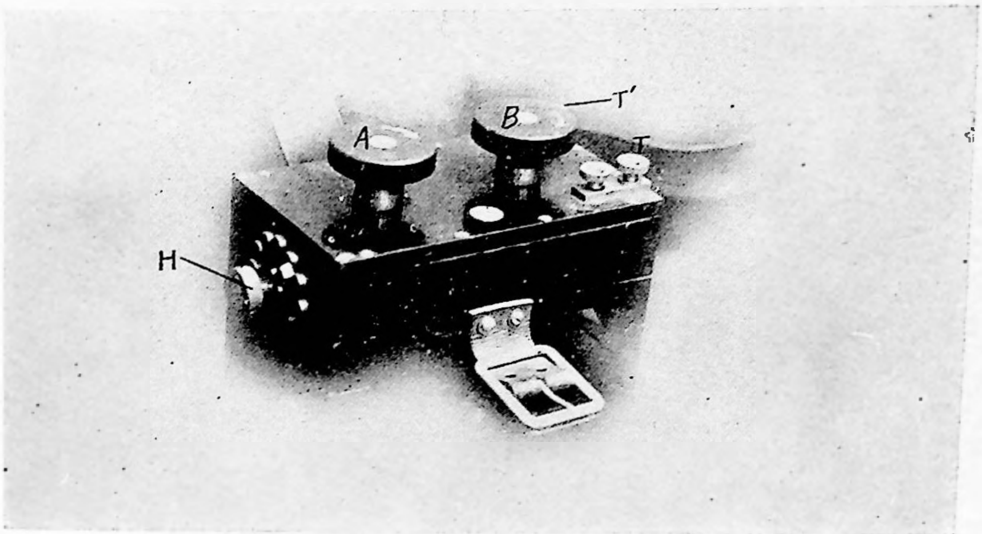


Fig. 15. Rheostat.

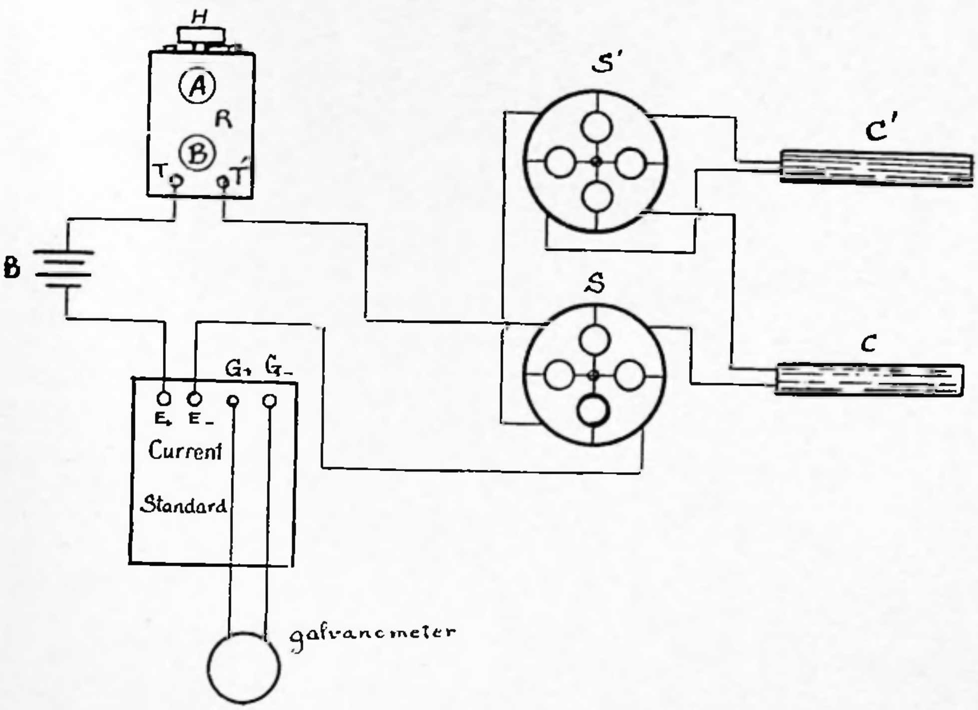


Fig. 16. Connecting Diagram of Electric Magnetometer.

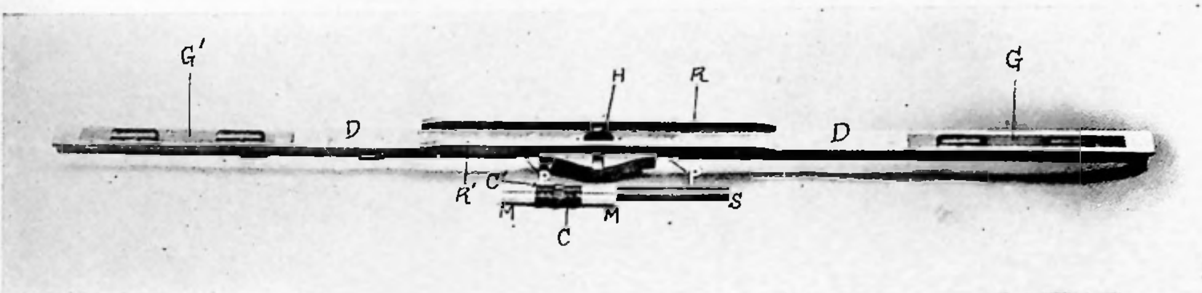


Fig. 17. Deflection Bar and Vibration Magnet.

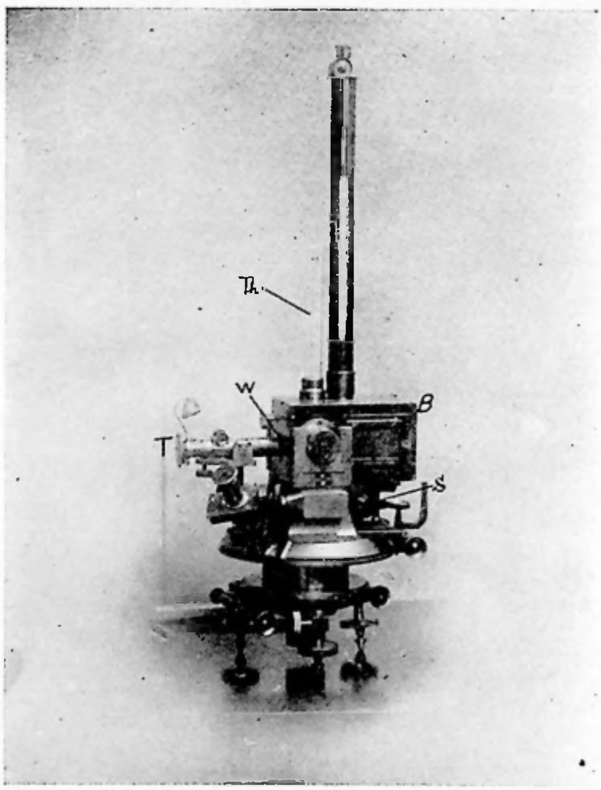


Fig. 18. Magnetometer for Gauss-Lamont's Method.
(Observation of Vibration.)

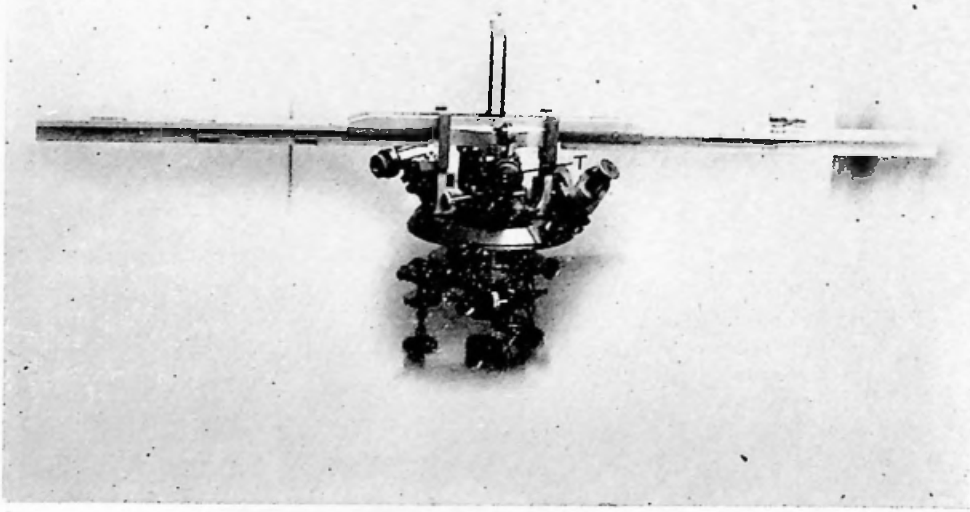


Fig. 19. Magnetometer for Gauss-Lamont's Method.
(Observation of Deflection).

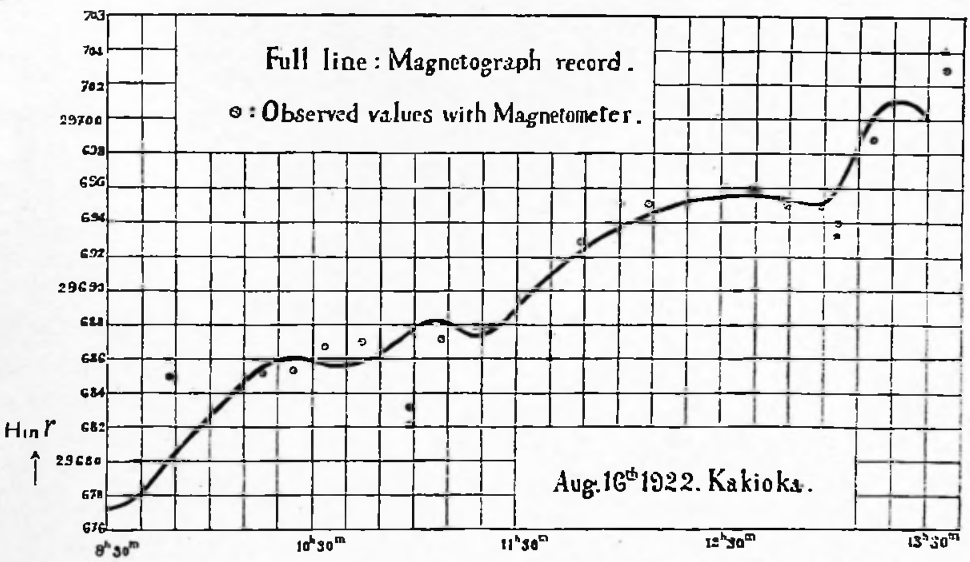


Fig. 20. Variation of Horizontal Intensity.

It should be noted here that the sensibility of the magnetograph is about 5 gamma per millimeter and the breath of its curve about a millimeter.

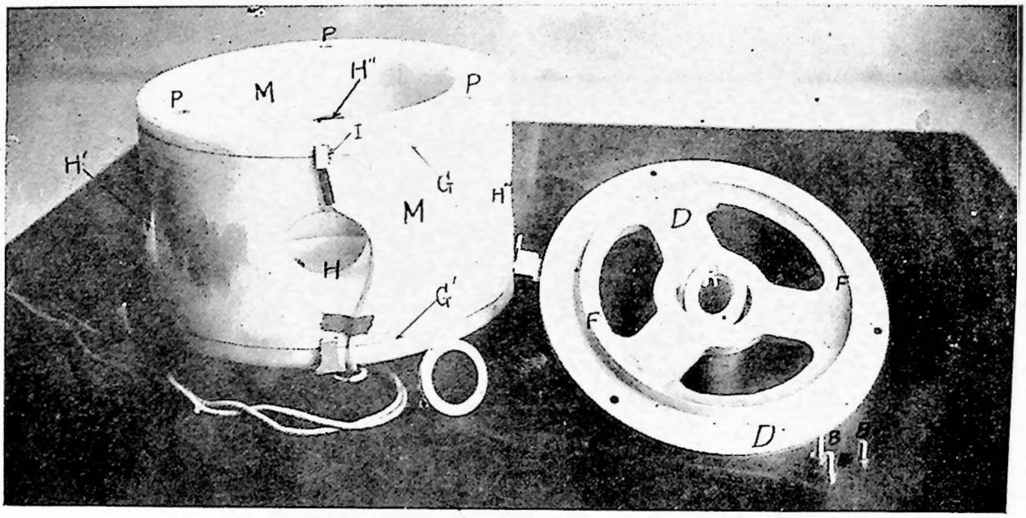


Fig. 21. Marble Standard Coil.

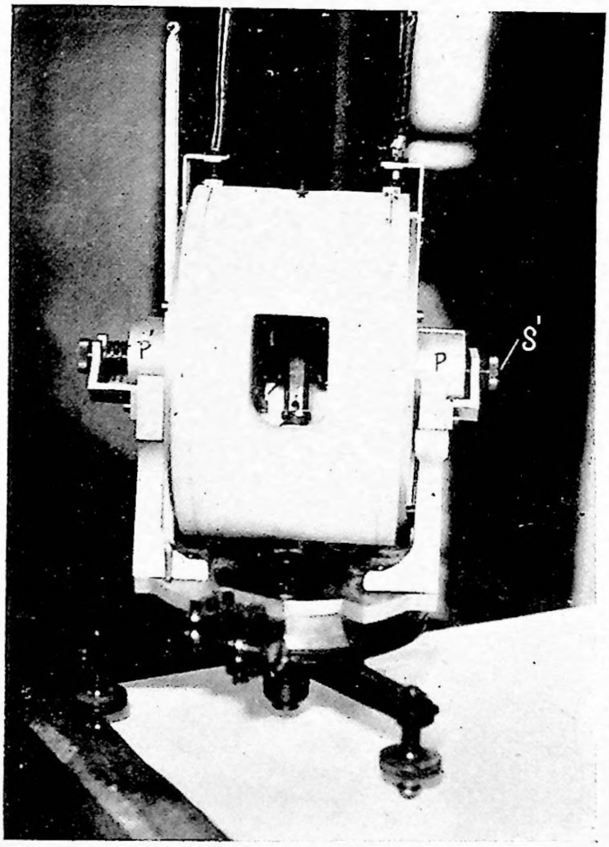


Fig. 22. Standard Coil on its Support.

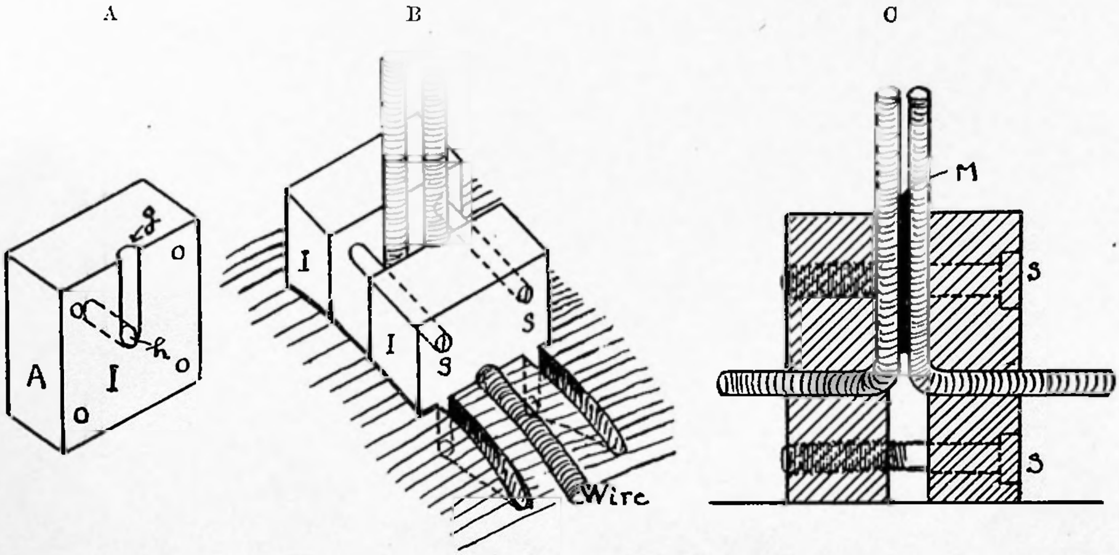


Fig. 23. Ends of Wire of Standard Coil.

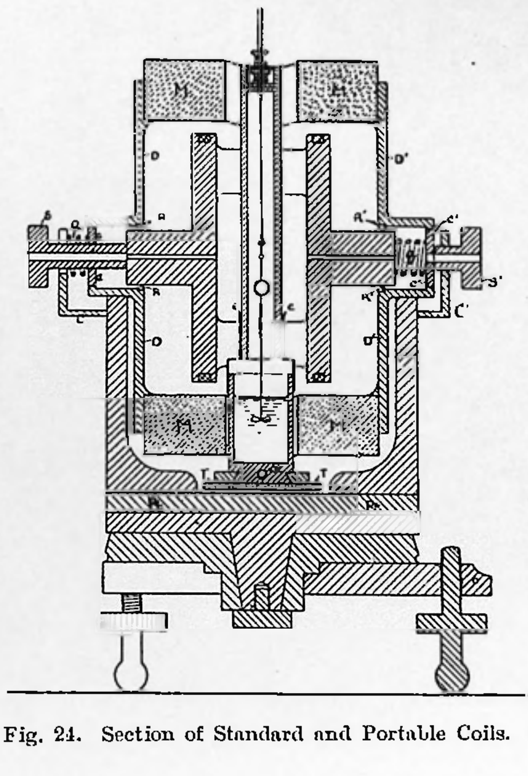


Fig. 24. Section of Standard and Portable Coils.

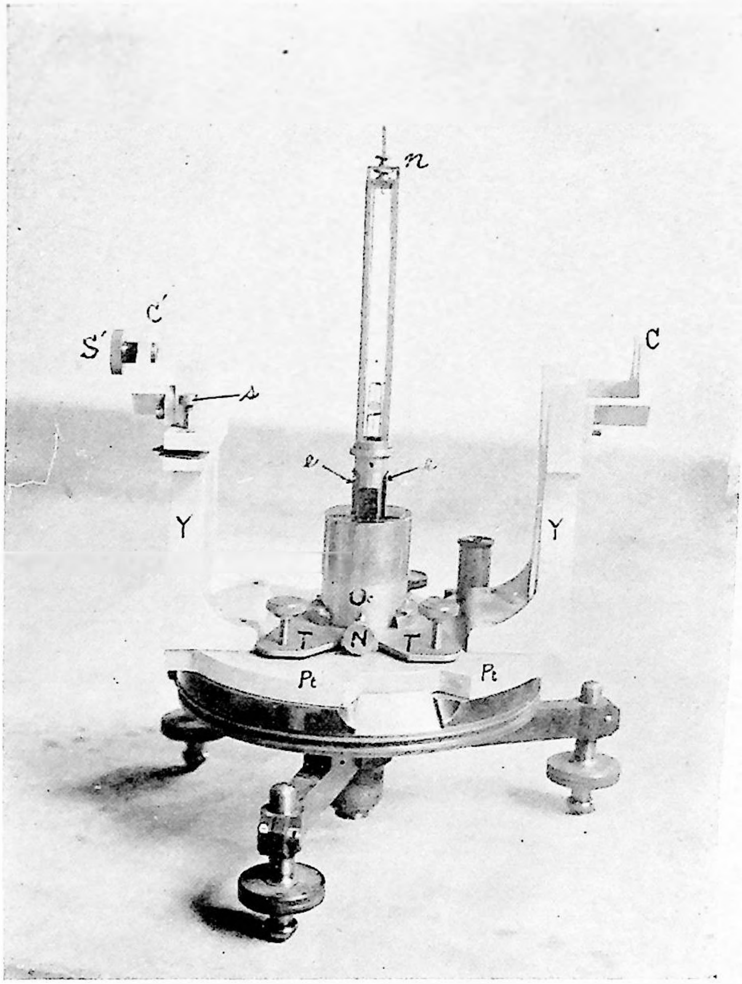


Fig. 25. Support of Standard Coil with Hanging Magnet.

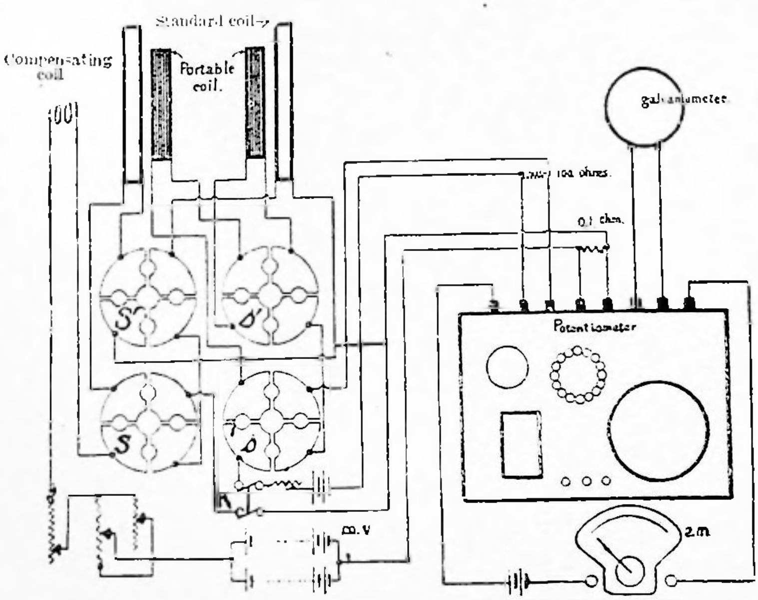


Fig. 26. Connection Diagram of Standardization of Coil.

Fig. 27. Sections of Connector.

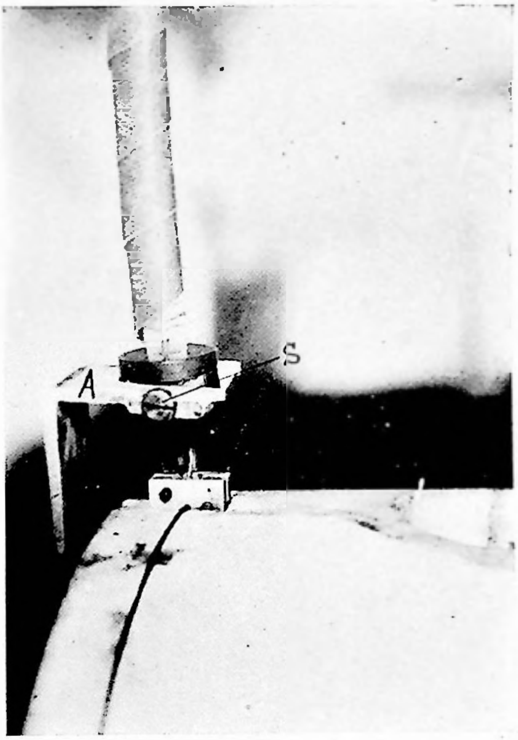


Fig. 28. Ends of Wire of Standard Coil,

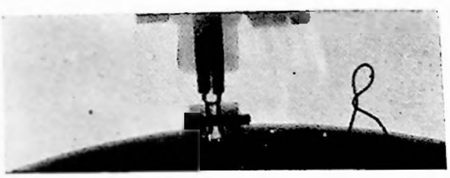


Fig. 29. X Ray Photograph of Ends of Standard Coil.

Secular Variation of Declination

at 11 magnetic observatories in and around the Pacific Ocean.

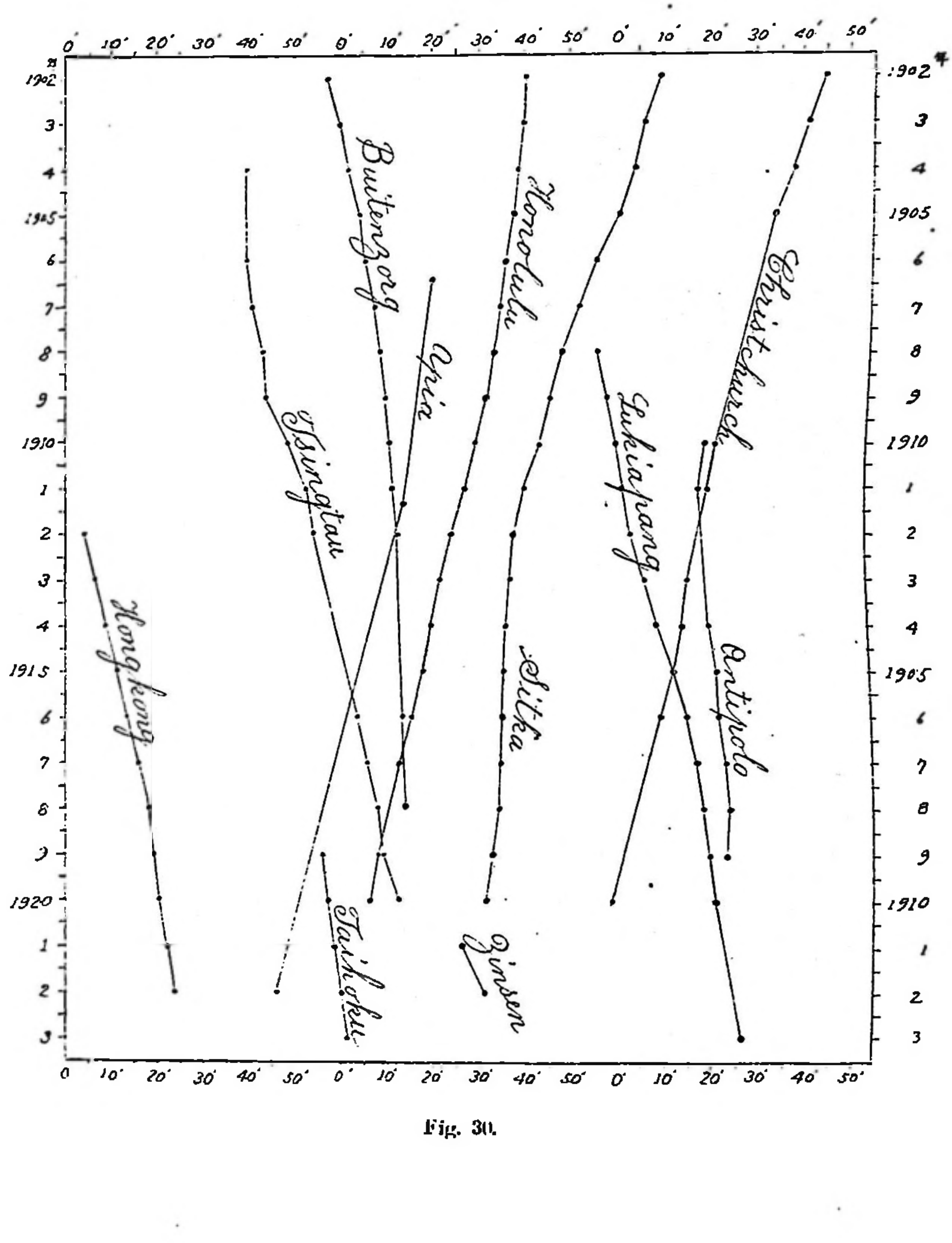


Fig. 30.

Secular Variation of Dip

at 10 magnetic observatories in and around the Pacific Ocean.

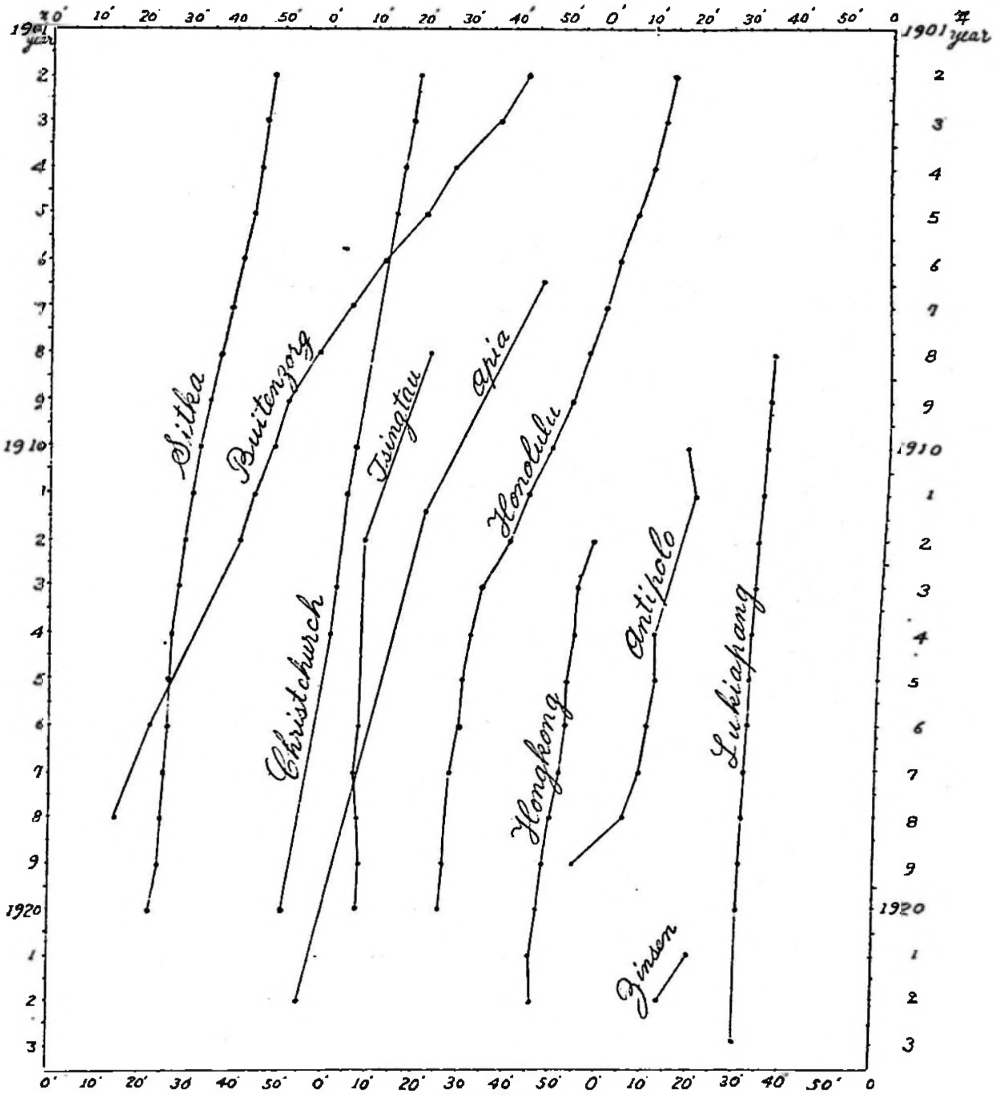


Fig. 31

Secular Variation of Horizontal Intensity

at 9 magnetic observatories in and around the Pacific Ocean.

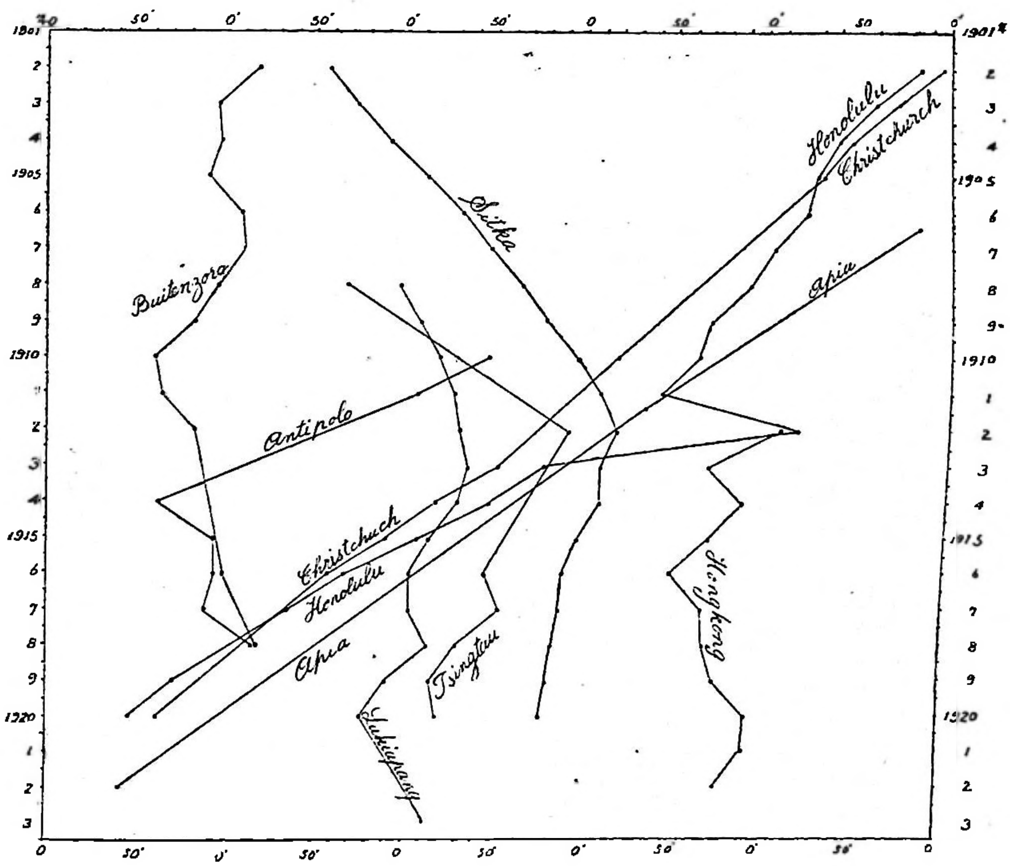


Fig. 32.

Secular Variation of Declination

at 14 stations in Japan observed four times repeatation.

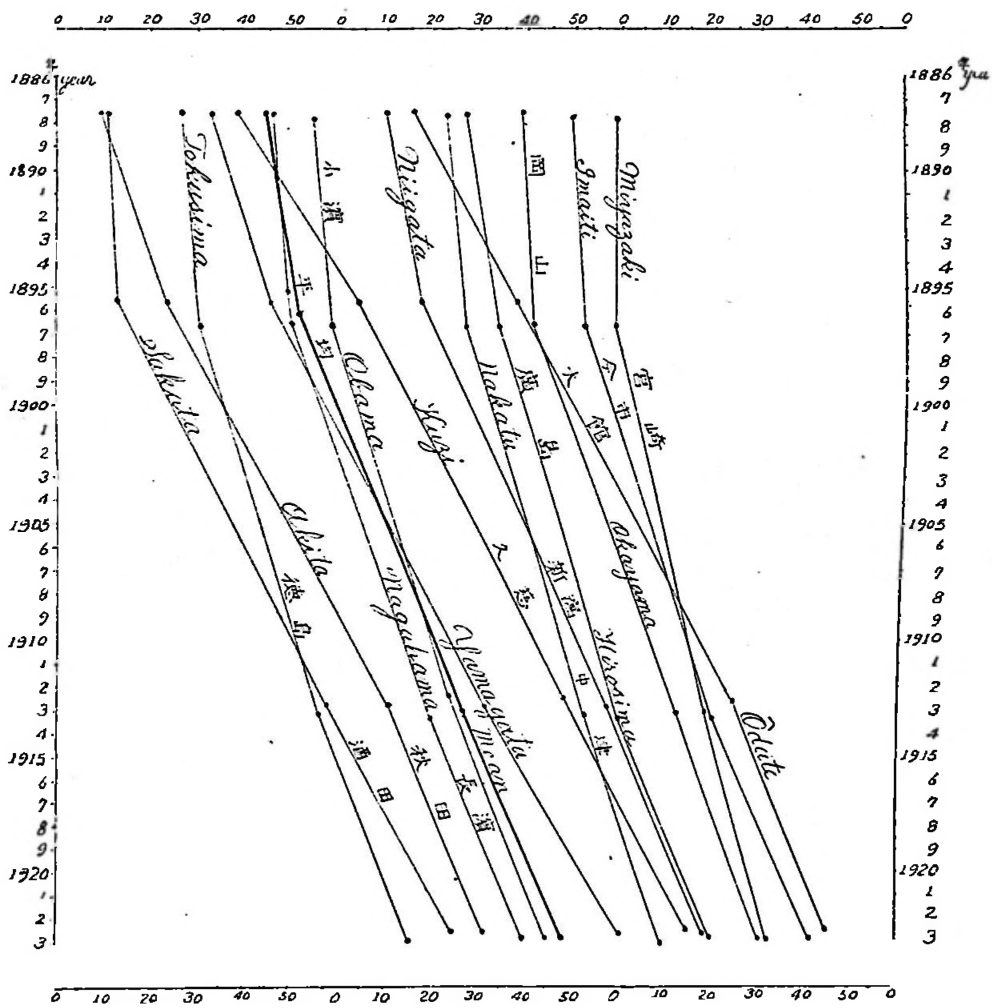


Fig. 33.

Secular Variation of Declination

at 43 stations in Japan observed thrice repeatation.

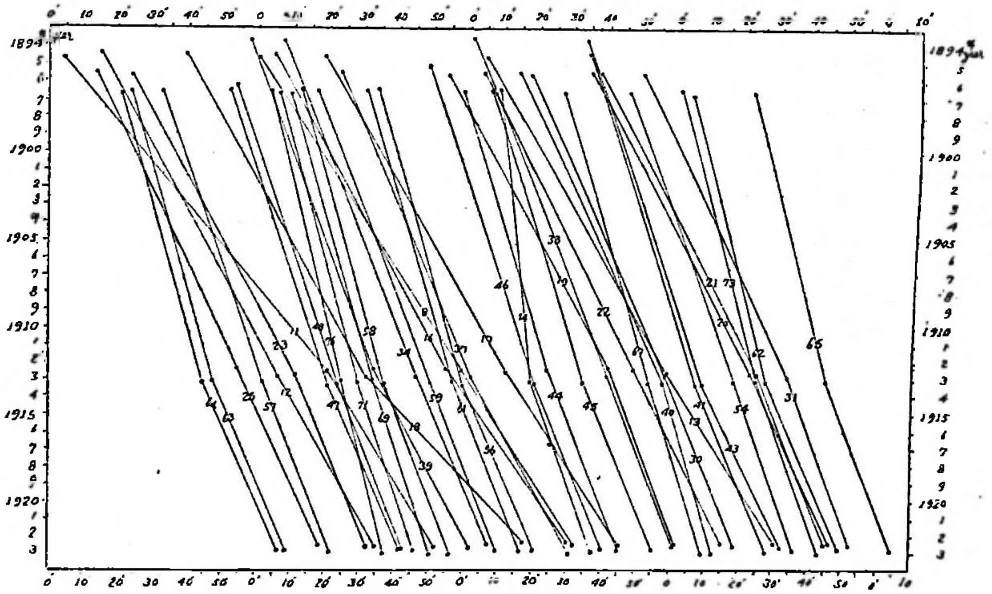


Fig. 34

Secular Variation of Dip

at 14 stations in Japan observed four times repeatatation.

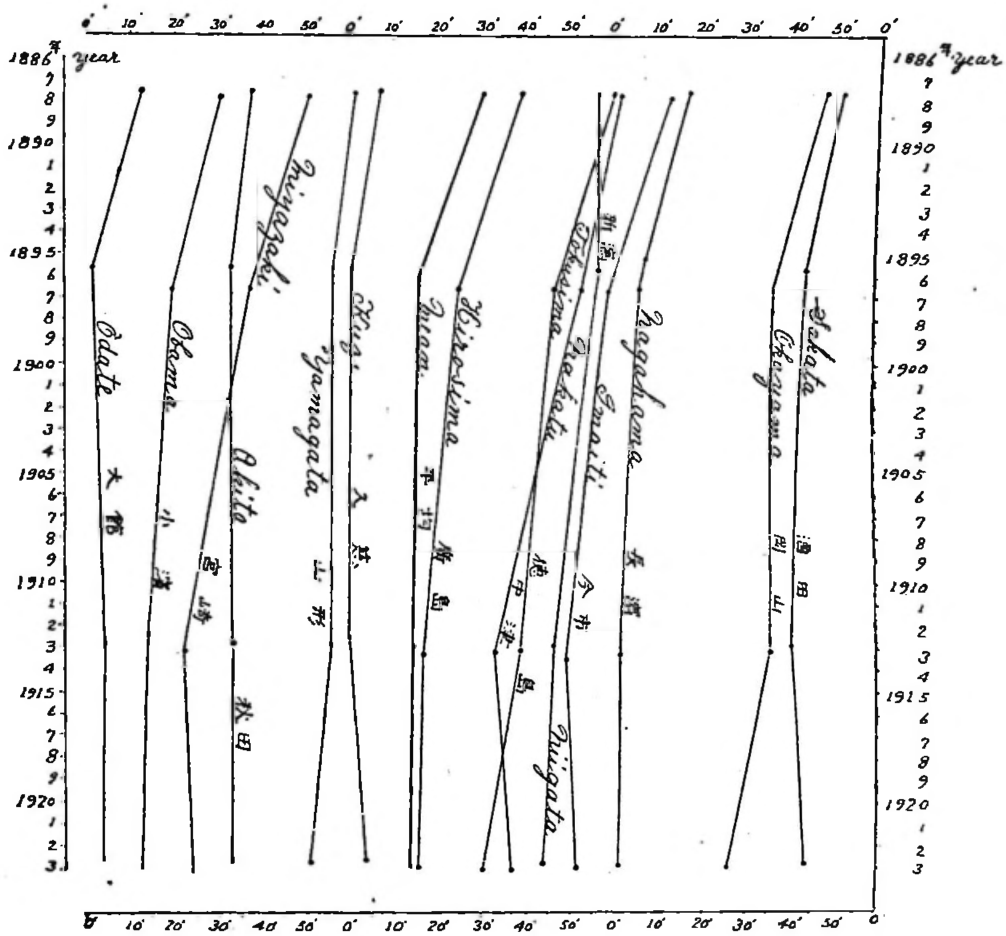


Fig. 35.

Secular Variation of Horizontal Intensity

at 14 stations in Japan observed four times repeatation.

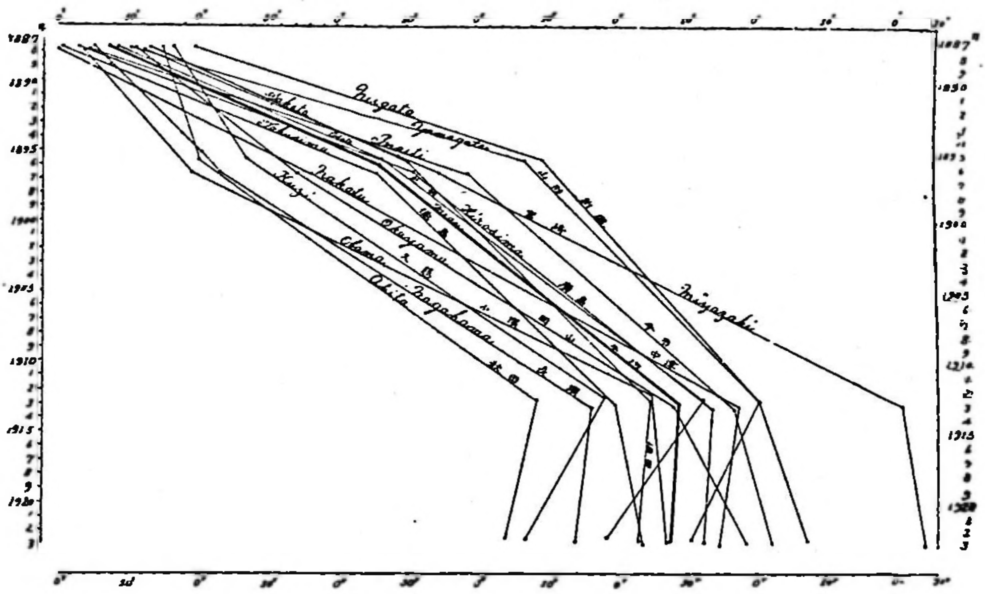


Fig. 36.

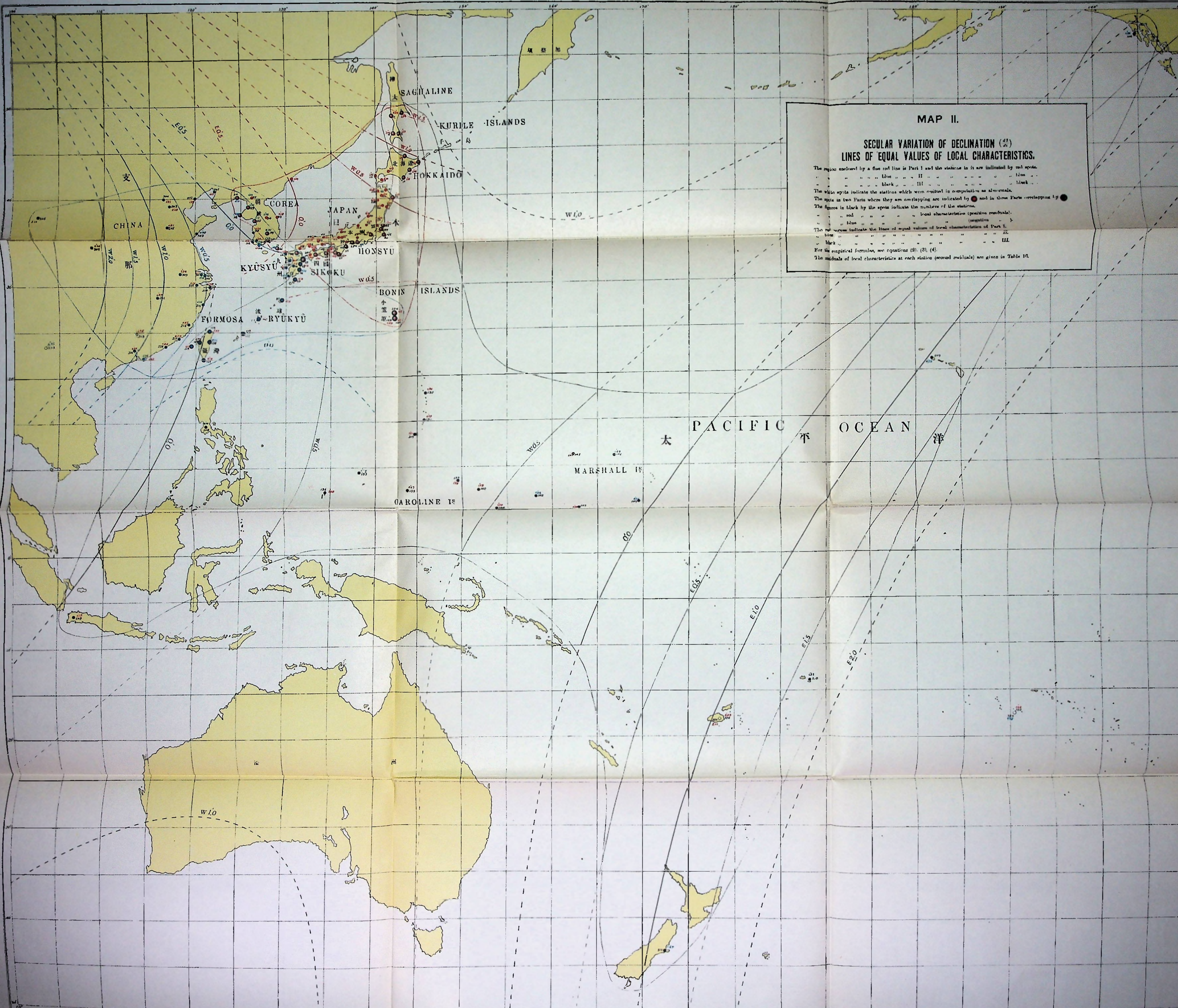
大正十五年八月十日印刷
大正十五年八月十五日發行

非賣品

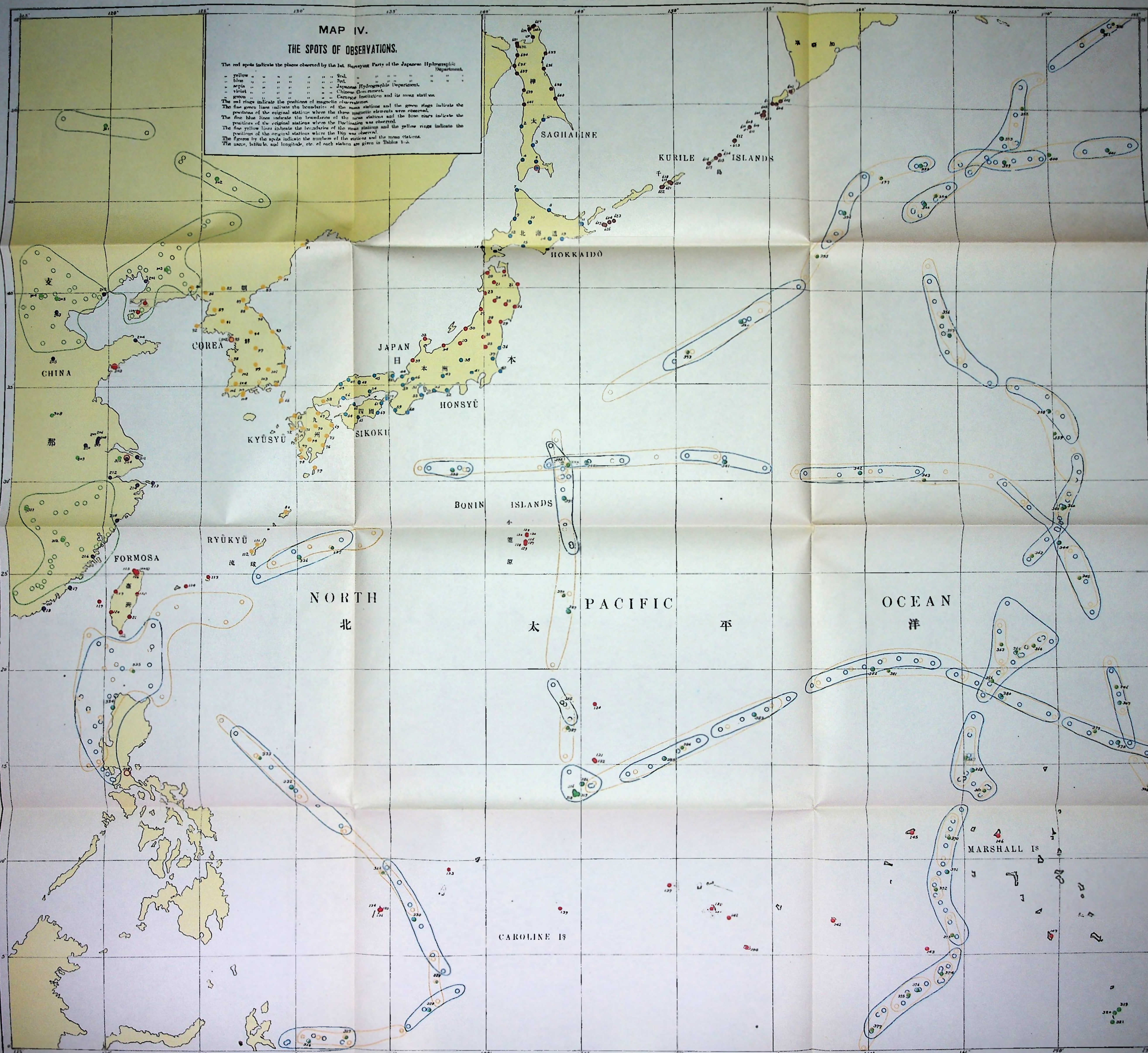
發行者　水路部

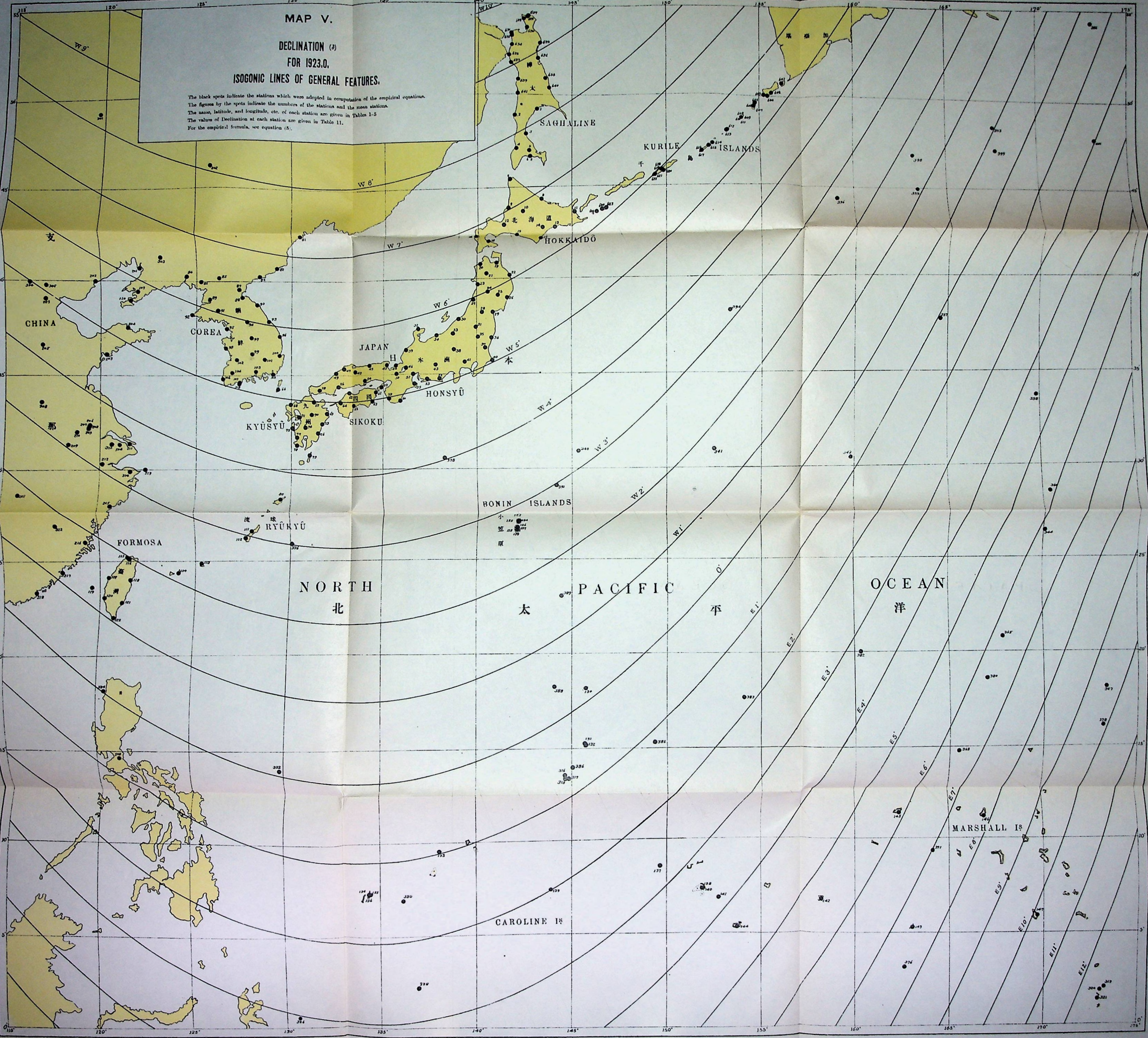
印刷者　株式會社秀英舍


MAP I.
SECULAR VARIATION OF DECLINATION ($\frac{dD}{dt}$)
FOR 1913-1923.
LINES OF EQUAL VALUES OF GENERAL FEATURES.
The ◎ spots indicate the stations of observations reported by the Japanese Hydrographic Department.
" ● " " " " " " " " " Chinese Government and the Carnegie Institution.
" ⊕ " " " " " " " " " Carnegie Institution.
The ⊙ spots indicate the positions of magnetic observatories.
The figures by the spots indicate the numbers of the stations.
The name, latitude, and longitude of each station are given in Tables 1-4.
The values of Secular Variation at each station are given in Table 8.
For the empirical formula, see equation (1).
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
JAPAN
COREA
CHINA
支那
KYÛSYÛ
SIKOKU
HONSYÛ
BONIN ISLANDS
FORMOSA
RYÛKYÛ
PACIFIC OCEAN
太平洋
MARSHALL I^s
CAROLINE I^s
W 4.5
W 4.0
W 3.5
W 3.0
W 2.5
W 2.0
W 1.5
W 1.0
W 0.5
E 0.5
E 1.0
E 1.5
E 2.0

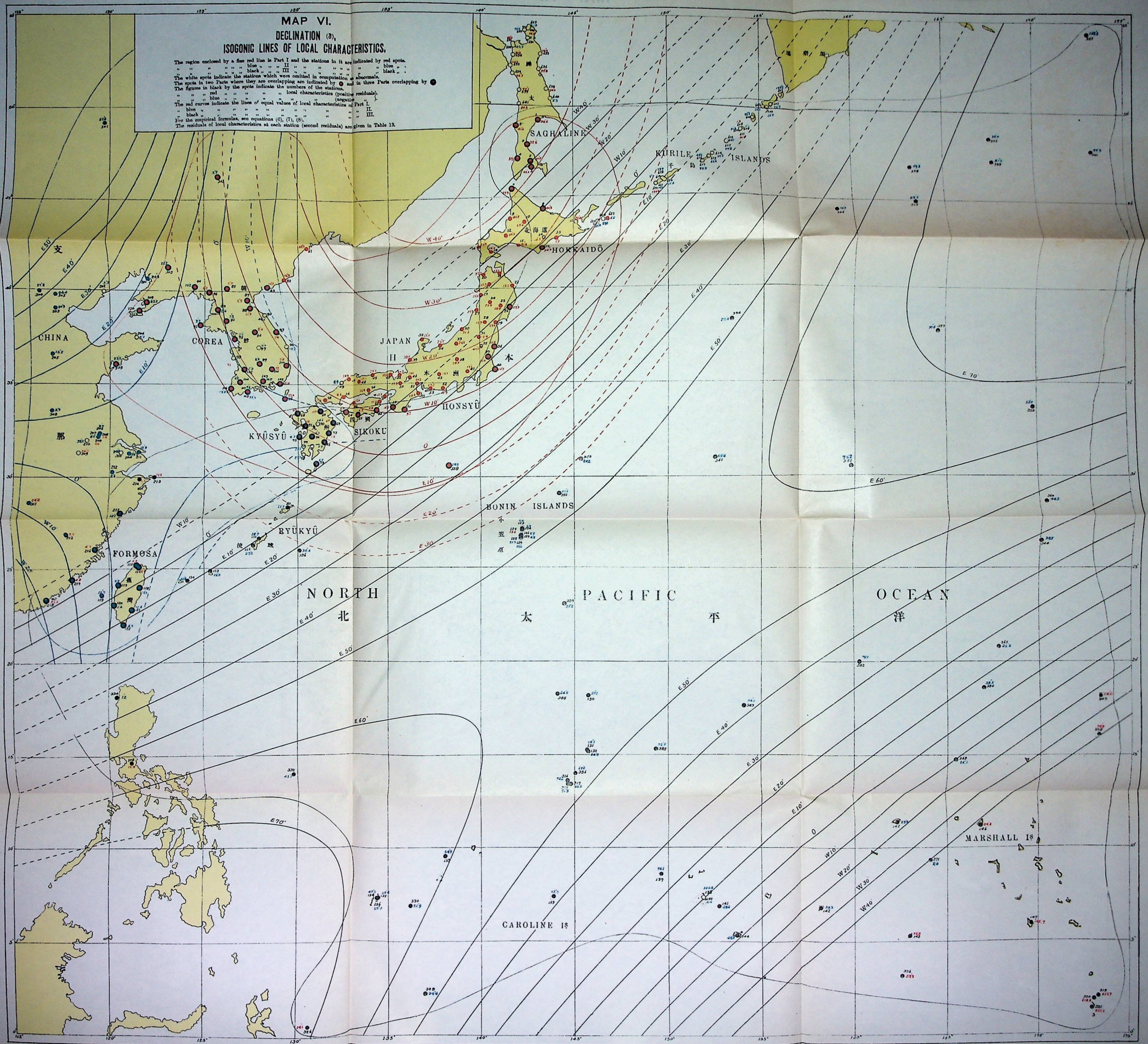

MAP II.
SECULAR VARIATION OF DECLINATION ($\frac{dD}{dt}$)
LINES OF EQUAL VALUES OF LOCAL CHARACTERISTICS.
The region enclosed by a fine red line is Part I and the stations in it are indicated by red spots.
" " " " " " blue " " " II " " " " " " " " blue " .
" " " " " " black " " " III " " " " " " " " black " .
The white spots indicate the stations which were omitted in computation as abnormals.
The spots in two Parts where they are overlapping are indicated by ● and in three Parts overlapping by ●
The figures in black by the spots indicate the numbers of the stations.
" " " red " " " " " local characteristics (positive residuals).
" " " blue " " " " " " (negative ").
The red curves indicate the lines of equal values of local characteristics of Part I.
" blue " " " " " " " " " II.
" black " " " " " " " " " III.
For the empirical formulae, see equations (2), (3), (4).
The residuals of local characteristics at each station (second residuals) are given in Table 10.
SAGHALINE
KURILE ISLANDS
HOKKAIDO
COREA
JAPAN
CHINA
HONSYU
KYUSYU
SIKOKU
BONIN ISLANDS
FORMOSA
RYUKYU
PACIFIC OCEAN
MARSHALL Is
CAROLINE Is
支那
太平洋
W1'0
W0'5
W1'5
W2'0
0'0
E0'5
E1'0
E1'5
E2'0

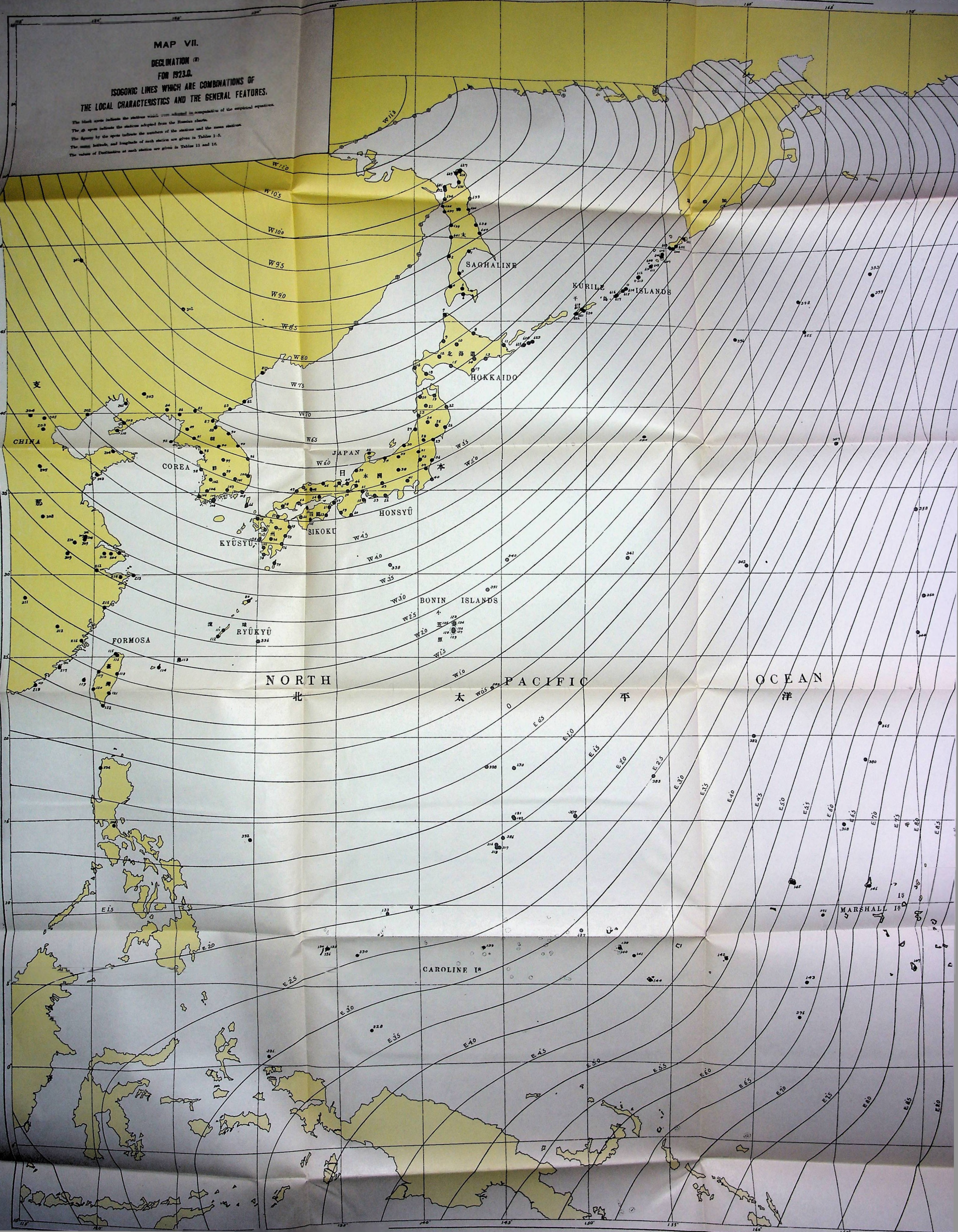
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
JAPAN
HONSYÛ
KYÛSYÛ
SIKOKU
CHINA
COREA
FORMOSA
RYÛKYÛ
BONIN ISLANDS
CAROLINE IS
MARSHALL IS
PACIFIC 太 平 OCEAN 洋
W40
W35
W30
W25
W20
W15
W10
W05
0.0
E05
E10
E15
E20
MAP III.
SECULAR VARIATION OF DECLINATION (永)
FOR 1913-1923.
LINES OF EQUAL VALUES WHICH ARE COMBINATIONS OF
THE LOCAL CHARACTERISTICS AND THE GENERAL FEATURES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The figures by the spots indicate the numbers of the stations.
The name, latitude, and longitude of each station are given in Tables 1-4.
The values of Secular Variation at each station are given in Table 8.

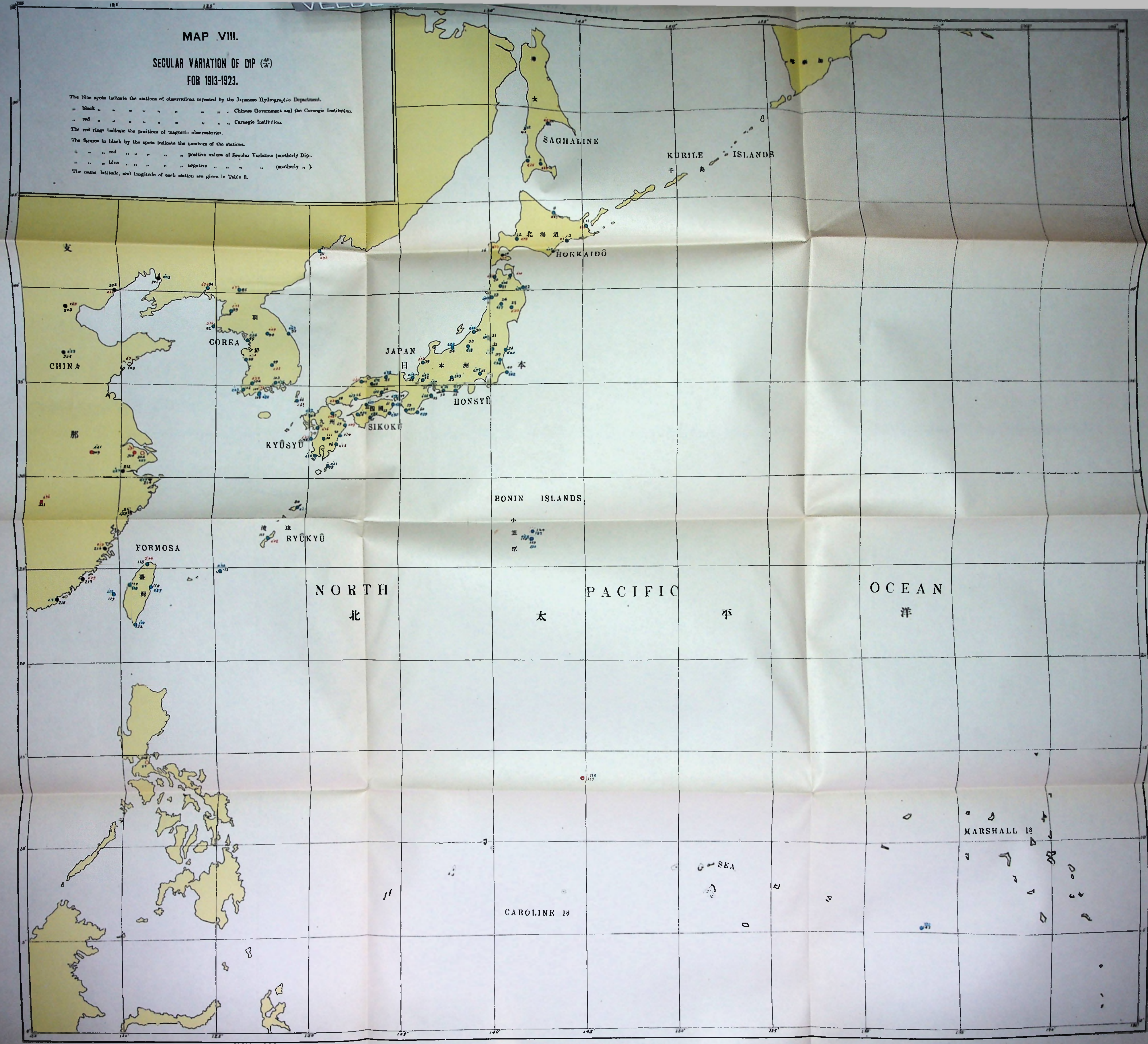

MAP IV.
THE SPOTS OF OBSERVATIONS.
The red spots indicate the places observed by the 1st. Surveying Party of the Japanese Hydrographic Department.
" yellow " " " " " " " 2nd. " " " " " " "
" blue " " " " " " " 3rd. " " " " " " "
" sepia " " " " " " " Japanese Hydrographic Department.
" violet " " " " " " " Chinese Government.
" green " " " " " " " Carnegie Institution and its mean stations.
The red rings indicate the positions of magnetic observations.
The fine green lines indicate the boundaries of the mean stations and the green rings indicate the positions of the original stations where the three magnetic elements were observed.
The fine blue lines indicate the boundaries of the mean stations and the blue rings indicate the positions of the original stations where the Declination was observed.
The fine yellow lines indicate the boundaries of the mean stations and the yellow rings indicate the positions of the original stations where the Dip was observed.
The figures by the spots indicate the numbers of the stations and the mean stations.
The name, latitude, and longitude, etc. of each station are given in Tables 1-5.
SAGHALINE
KURILE ISLANDS
HOKKAIDŌ
JAPAN
HONSYŪ
SIKOKU
KYŪSYŪ
COREA
CHINA
FORMOSA
RYŪKYŪ
BONIN ISLANDS
NORTH PACIFIC OCEAN
北太平洋
MARSHALL Is
CAROLINE Is



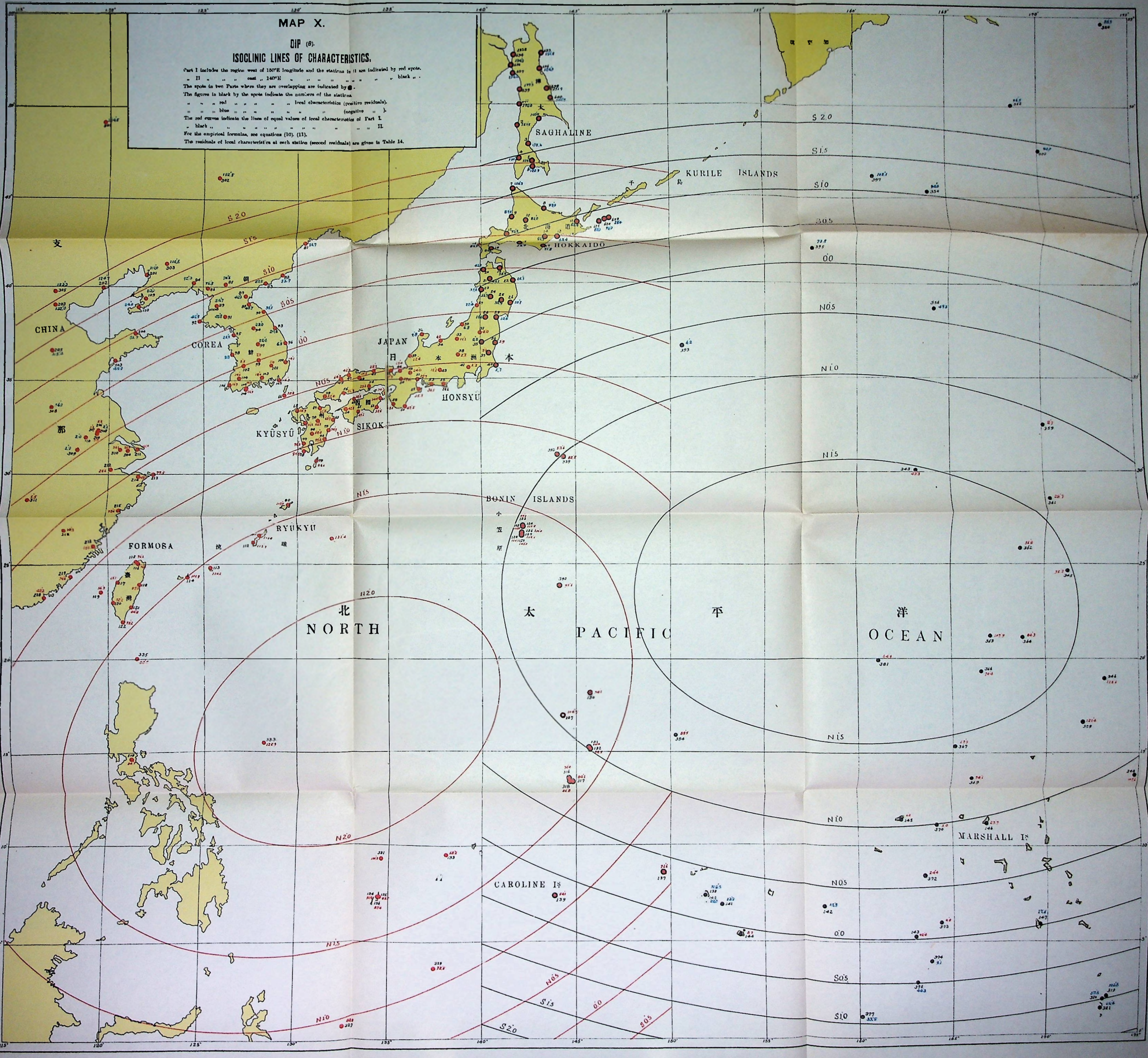
MAP V.
DECLINATION (δ)
FOR 1923.0.
ISOGONIC LINES OF GENERAL FEATURES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The figures by the spots indicate the numbers of the stations and the mean stations.
The name, latitude, and longitude, etc. of each station are given in Tables 1-5
The values of Declination at each station are given in Table 11.
For the empirical formula, see equation (5).
SAGHALINE
KURILE ISLANDS
HOKKAIDŌ
CHINA
COREA
JAPAN
HONSYŪ
KYŪSYŪ
SIKOKU
RYŪKYŪ
FORMOSA
BONIN ISLANDS
NORTH PACIFIC OCEAN
北 太 平 洋
MARSHALL Is
CAROLINE Is
W 9°
W 8°
W 7°
W 6°
W 5°
W 4°
W 3°
W 2°
W 1°
0
E 1°
E 2°
E 3°
E 4°
E 5°
E 6°
E 7°
E 8°
E 9°
E 10°
E 11°
E 12°

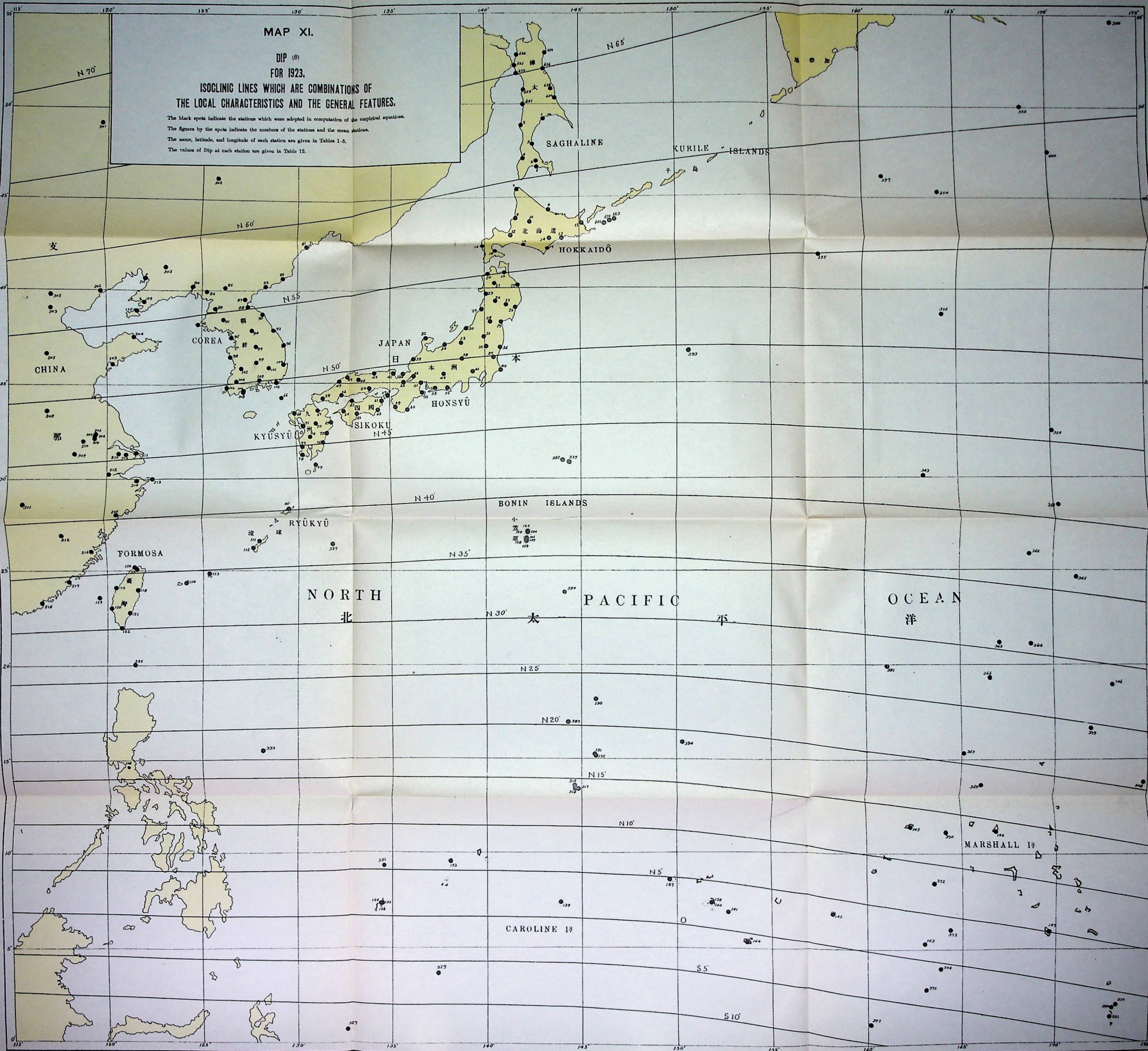

MAP VI.
DECLINATION (δ),
ISOGONIC LINES OF LOCAL CHARACTERISTICS.
The region enclosed by a fine red line is Part I and the stations in it are indicated by red spots.
" " " " " " blue " " " II " " " " " " " blue " .
" " " " " " black " " " III " " " " " " " black " .
The white spots indicate the stations which were omitted in computation as abnormals.
The spots in two Parts where they are overlapping are indicated by ● and in three Parts overlapping by ●
The figures in black by the spots indicate the numbers of the stations.
" " " red " " " " " local characteristics (positive residuals).
" " " blue " " " " " " " (negative ").
The red curves indicate the lines of equal values of local characteristics of Part I.
" blue " " " " " " " " " " " II.
" black " " " " " " " " " " " III.
For the empirical formulas, see equations (6), (7), (8).
The residuals of local characteristics at each station (second residuals) are given in Table 13.
CHINA
支
那
COREA
JAPAN
日
本
SAGHALINE
KURILE ISLANDS
HOKKAIDŌ
HONSYŪ
SIKOKU
KYŪSYŪ
RYŪKYŪ
FORMOSA
BONIN ISLANDS
NORTH PACIFIC OCEAN
北 太 平 洋
CAROLINE IS
MARSHALL IS
E 70°
E 60°
E 50°
E 40°
E 30°
E 20°
E 10°
0
W 10°
W 20°
W 30°
W 40°
120°
125°
130°
135°
140°
145°
150°
155°
160°
165°
170°
175°

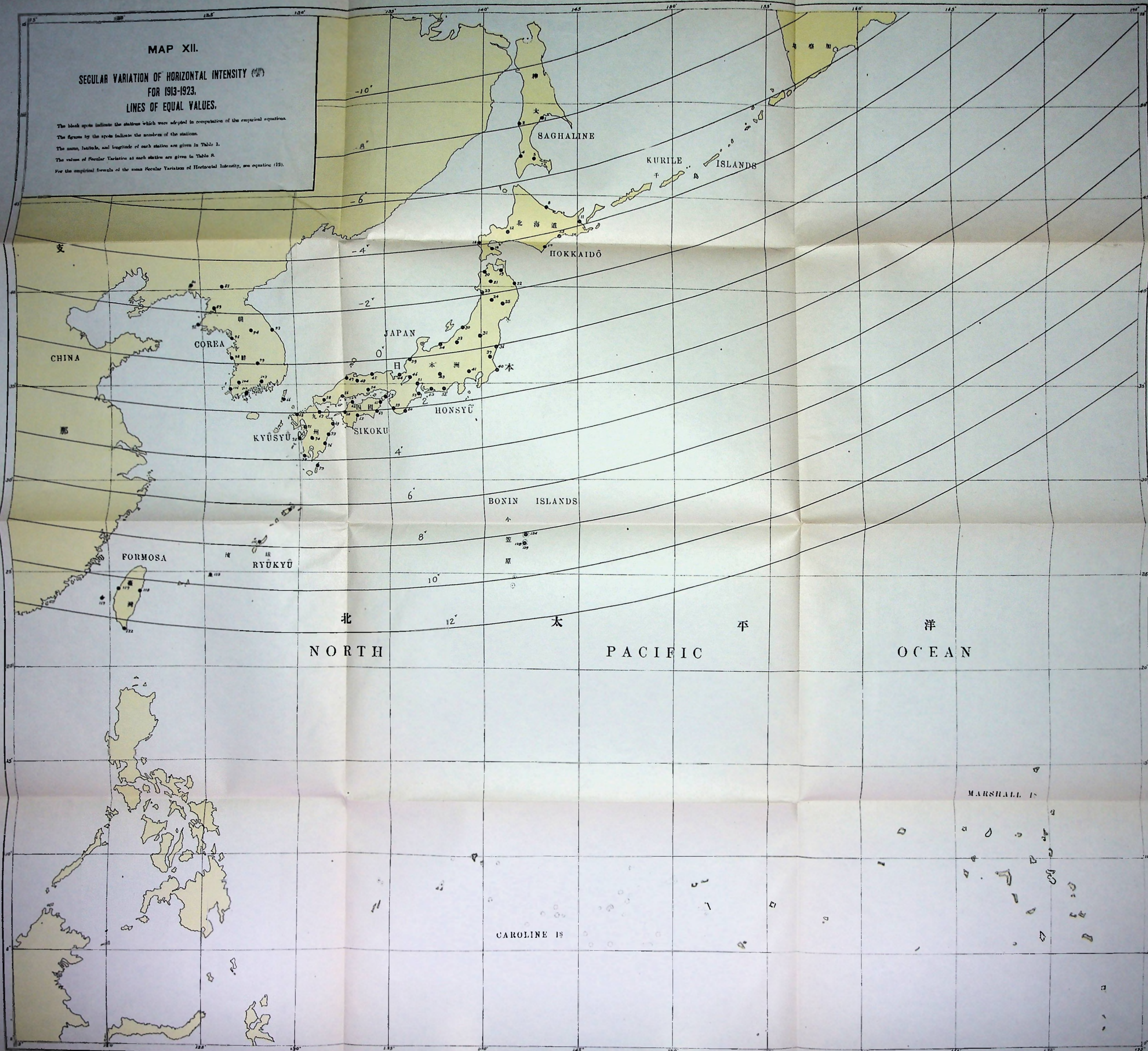

MAP VII.
DECLINATION (D)
FOR 1923.0.
ISOGONIC LINES WHICH ARE COMBINATIONS OF
THE LOCAL CHARACTERISTICS AND THE GENERAL FEATURES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The ⊕ spots indicate the stations adopted from the Russian charts.
The figures by the spots indicate the numbers of the stations and the mean stations.
The names, latitude, and longitude of each station are given in Tables 1-5.
The values of Declination at each station are given in Tables 11 and 16.
SAGHALINE
KURILE ISLANDS
HOKKAIDO
JAPAN
HONSYÛ
SIKOKU
KYÛSYÛ
COREA
CHINA
FORMOSA
RYÛKYÛ
BONIN ISLANDS
NORTH PACIFIC OCEAN
北太平洋
CAROLINE Is
MARSHALL Is

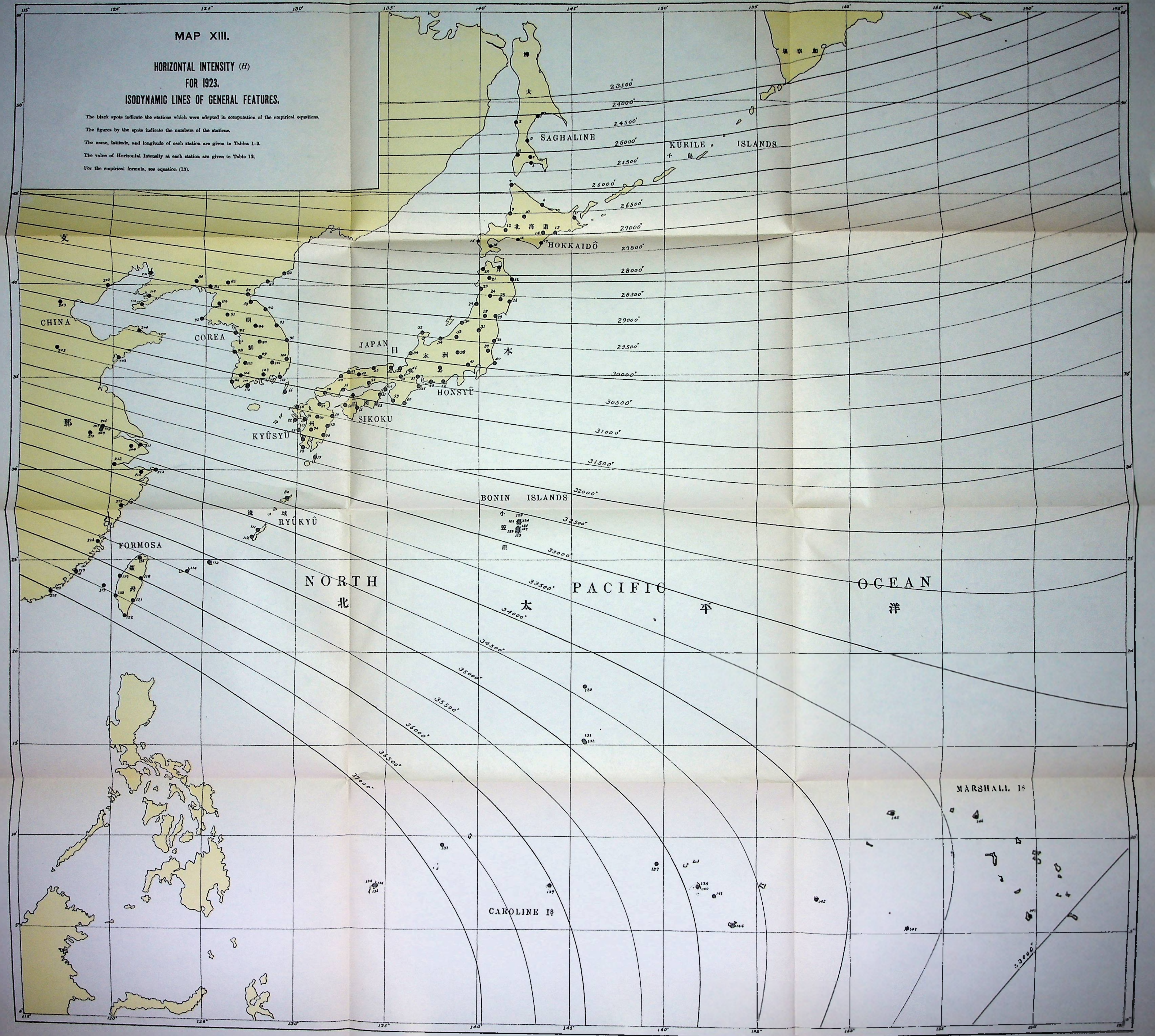

MAP VIII.
SECULAR VARIATION OF DIP ($\frac{d\theta}{dt}$)
FOR 1913-1923.
The blue spots indicate the stations of observations repeated by the Japanese Hydrographic Department.
" black " " " " " " " " " Chinese Government and the Carnegie Institution.
" red " " " " " " " " " Carnegie Institution.
The red rings indicate the positions of magnetic observatories.
The figures in black by the spots indicate the numbers of the stations.
" " " red " " " " " positive values of Secular Variation (northerly Dip.
" " " blue " " " " " negative " " " " (southerly ").
The name, latitude, and longitude of each station are given in Table 8.
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
JAPAN
HONSYÛ
SIKOKU
KYÛSYÛ
COREA
CHINA
FORMOSA
RYÛKYÛ
BONIN ISLANDS
NORTH PACIFIC OCEAN
北太平洋
MARSHALL Is
CAROLINE Is


MAP IX.
DIP (θ)
FOR 1923.
ISOCLINIC LINES OF GENERAL FEATURES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The figures by the spots indicate the numbers of the stations and the mean stations.
The name, latitude, and longitude of each station are given in Tables 1-5.
The values of Dip at each station are given in Table 12.
For the empirical formula, see equation (9).
N 75°
N 70°
N 65°
N 60°
N 55°
N 50°
N 45°
N 40°
N 35°
N 30°
N 25°
N 20°
N 15°
N 10°
N 5°
0
S 5°
S 10°
SAGHALINE
KURILE ISLANDS
HOKKAIDŌ
CHINA
支
那
COREA
JAPAN
日本
HONSYŪ
SIKOKU
KYŪSYŪ
RYŪKYŪ
FORMOSA
BONIN ISLANDS
北
太
平
洋
NORTH
PACIFIC
OCEAN
MARSHALL Is
CAROLINE Is

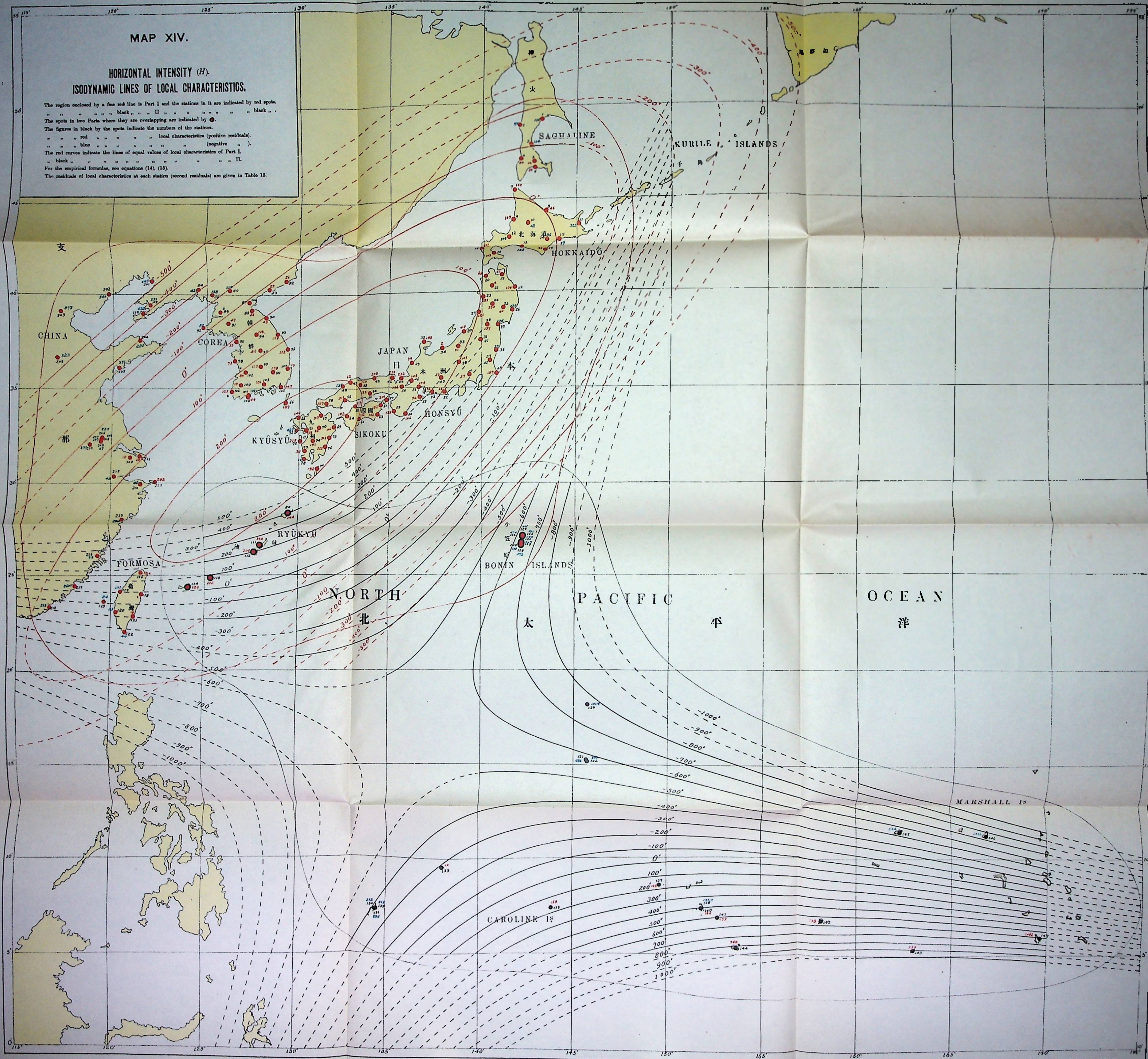

MAP X.
DIP (θ).
ISOCLINIC LINES OF CHARACTERISTICS.
Part I includes the region west of 150°E longitude and the stations in it are indicated by red spots.
„ II „ „ „ east „ 140°E „ „ „ „ „ „ „ „ „ black „ .
The spots in two Parts where they are overlapping are indicated by ●.
The figures in black by the spots indicate the numbers of the stations.
„ „ „ red „ „ „ „ „ local characteristics (positive residuals).
„ „ „ blue „ „ „ „ „ „ „ (negative „).
The red curves indicate the lines of equal values of local characteristics of Part I.
„ black „ „ „ „ „ „ „ „ „ „ „ „ II.
For the empirical formulas, see equations (10), (11).
The residuals of local characteristics at each station (second residuals) are given in Table 14.
SAGHALINE
KURILE ISLANDS
HOKKAIDO
JAPAN
日 本 州
HONSYU
KYŪSYŪ
SIKOK
CHINA
支 那
COREA
FORMOSA
RYUKYU
BONIN ISLANDS
NORTH
北
太
PACIFIC
平
洋
OCEAN
MARSHALL Is
CAROLINE Is
S 2.0
S 1.5
S 1.0
S 0.5
0.0
N 0.5
N 1.0
N 1.5
N 2.0


MAP XI.
DIP (θ)
FOR 1923.
ISOCLINIC LINES WHICH ARE COMBINATIONS OF
THE LOCAL CHARACTERISTICS AND THE GENERAL FEATURES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The figures by the spots indicate the numbers of the stations and the mean stations.
The name, latitude, and longitude of each station are given in Tables 1-5.
The values of Dip at each station are given in Table 12.
N 70°
N 65°
N 60°
N 55°
N 50°
N 45
N 40°
N 35°
N 30°
N 25°
N 20°
N 15°
N 10°
N 5°
S 5°
S 10°
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
JAPAN
日本
HONSYÛ
SIKOKU
KYÛSYÛ
COREA
CHINA
支那
RYÛKYÛ
BONIN ISLANDS
FORMOSA
NORTH PACIFIC OCEAN
北太平洋
CAROLINE Is
MARSHALL Is

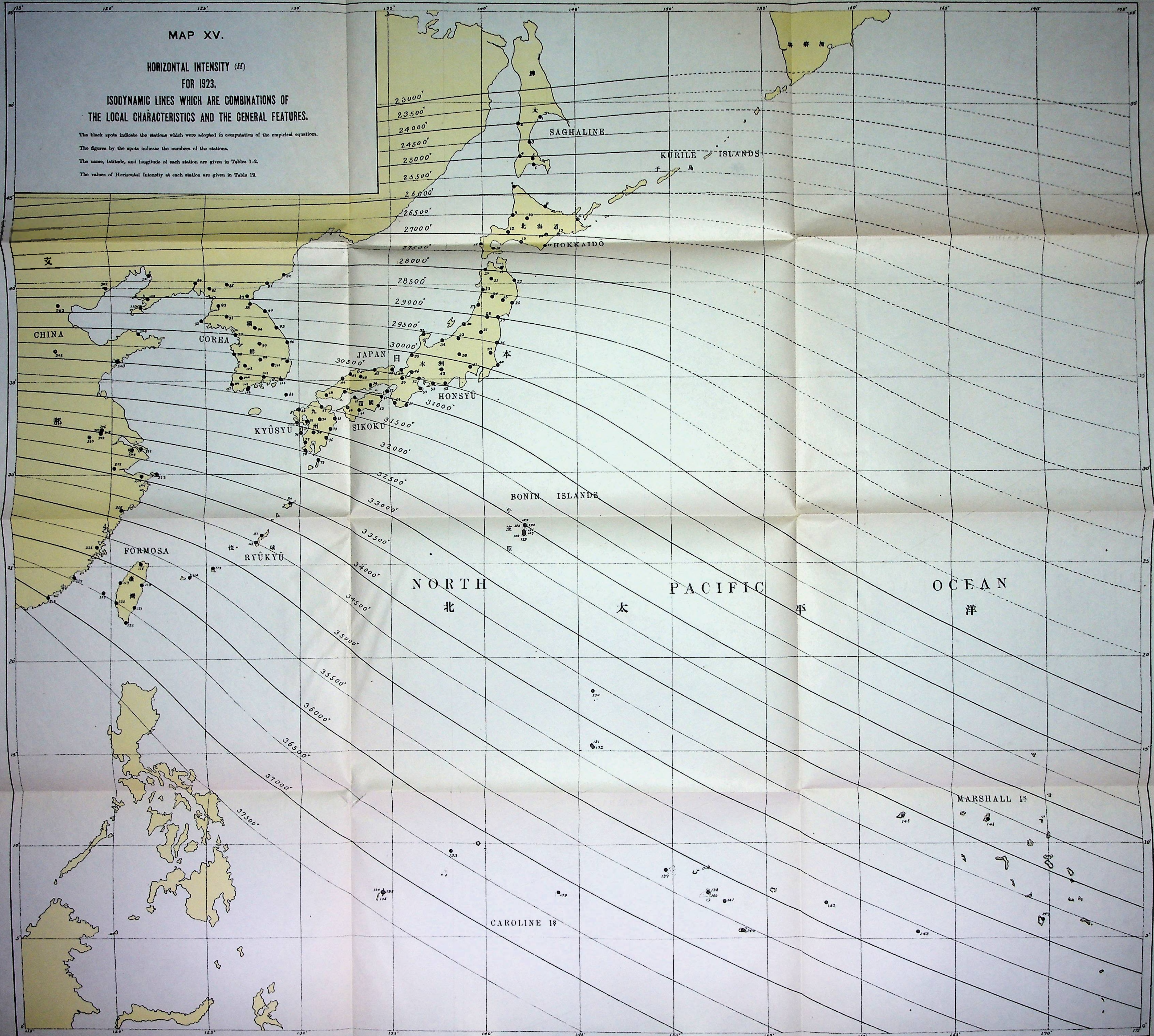

MAP XII.
SECULAR VARIATION OF HORIZONTAL INTENSITY ($\frac{dH}{dt}$)
FOR 1913-1923.
LINES OF EQUAL VALUES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The figures by the spots indicate the numbers of the stations.
The name, latitude, and longitude of each station are given in Table 1.
The values of Secular Variation at each station are given in Table 8.
For the empirical formula of the mean Secular Variation of Horizontal Intensity, see equation (12).
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
JAPAN
COREA
CHINA
HONSYÛ
SIKOKU
KYÛSYÛ
BONIN ISLANDS
FORMOSA
RYÛKYÛ
NORTH PACIFIC OCEAN
北太平洋
MARSHALL Is
CAROLINE Is
-10°
-8°
-6°
-4°
-2°
0°
2°
4°
6°
8°
10°
12°



MAP XIII.
HORIZONTAL INTENSITY (H)
FOR 1923.
ISODYNAMIC LINES OF GENERAL FEATURES.
The black spots indicate the stations which were adopted in computation of the empirical equations.
The figures by the spots indicate the numbers of the stations.
The name, latitude, and longitude of each station are given in Tables 1-2.
The value of Horizontal Intensity at each station are given in Table 12.
For the empirical formula, see equation (13).
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
CHINA
COREA
JAPAN
HONSYÛ
SIKOKU
KYÛSYÛ
RYÛKYÛ
FORMOSA
BONIN ISLANDS
NORTH PACIFIC OCEAN
北 太 平 洋
MARSHALL Is
CAROLINE Is
23500'
24000'
24500'
25000'
25500'
26000'
26500'
27000'
27500'
28000'
28500'
29000'
29500'
30000'
30500'
31000'
31500'
32000'
32500'
33000'
33500'
34000'
34500'
35000'
35500'
36000'
36500'
37000'
33000'
115°
120°
125°
130°
135°
140°
145°
150°
155°
160°
165°
170°



MAP XIV.
HORIZONTAL INTENSITY (H).
ISODYNAMIC LINES OF LOCAL CHARACTERISTICS.
The region enclosed by a fine red line is Part I and the stations in it are indicated by red spots.
" " " " " " black " " " II " " " " " " " " black " .
The spots in two Parts where they are overlapping are indicated by ●.
The figures in black by the spots indicate the numbers of the stations.
" " " red " " " " " local characteristics (positive residuals).
" " " blue " " " " " " " (negative ").
The red curves indicate the lines of equal values of local characteristics of Part I.
" black " " " " " " " " " " " II.
For the empirical formulas, see equations (14), (15).
The residuals of local characteristics at each station (second residuals) are given in Table 15.
CHINA
COREA
JAPAN
SAGHALINE
KURILE ISLANDS
HOKKAIDO
HONSYU
SIKOKU
KYUSYU
RYUKYU
FORMOSA
BONIN ISLANDS
NORTH PACIFIC OCEAN
北 太 平 洋
MARSHALL Is
CAROLINE Is



MAP XV.

HORIZONTAL INTENSITY (*H*)

FOR 1923.

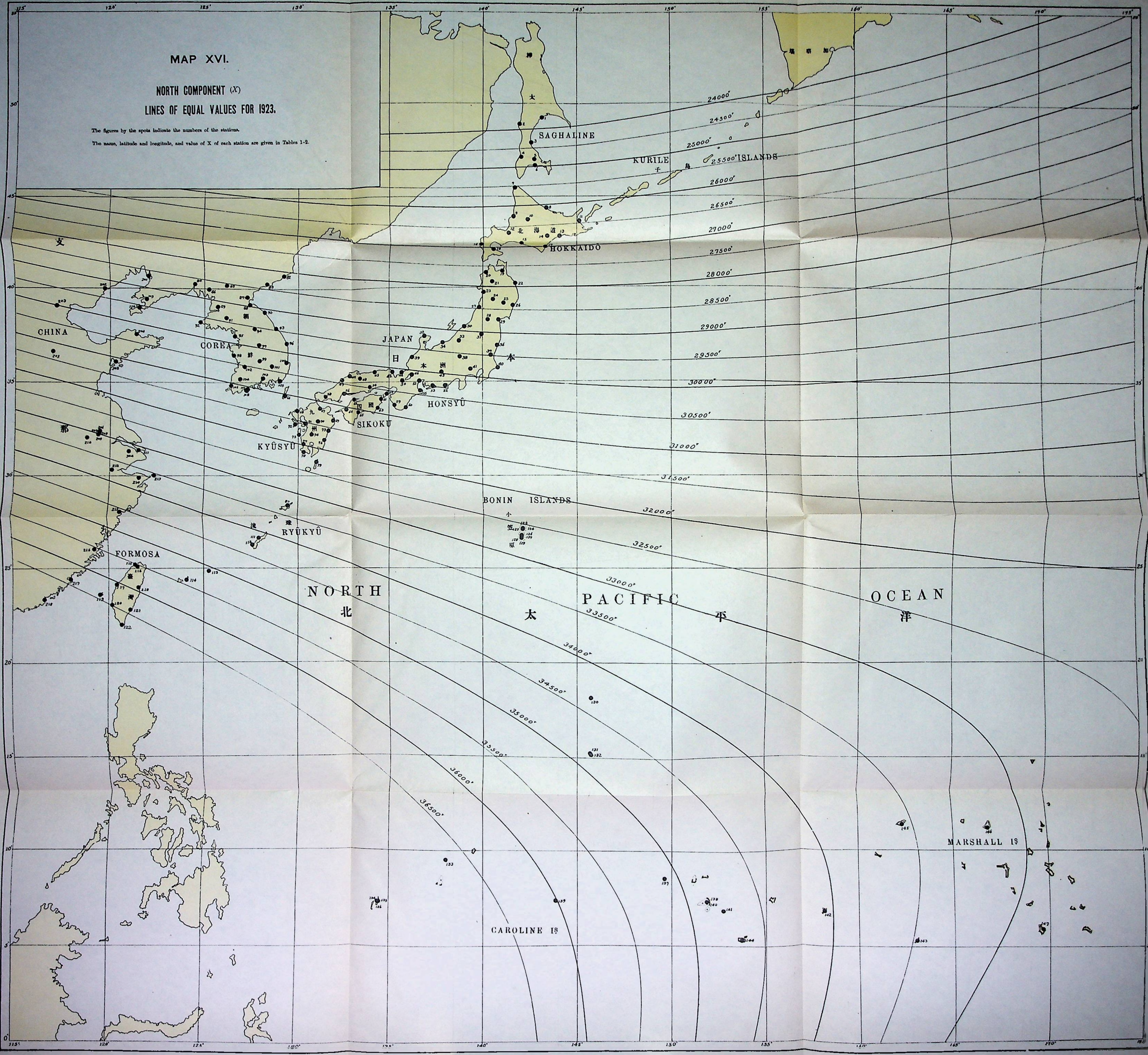
ISODYNAMIC LINES WHICH ARE COMBINATIONS OF THE LOCAL CHARACTERISTICS AND THE GENERAL FEATURES.

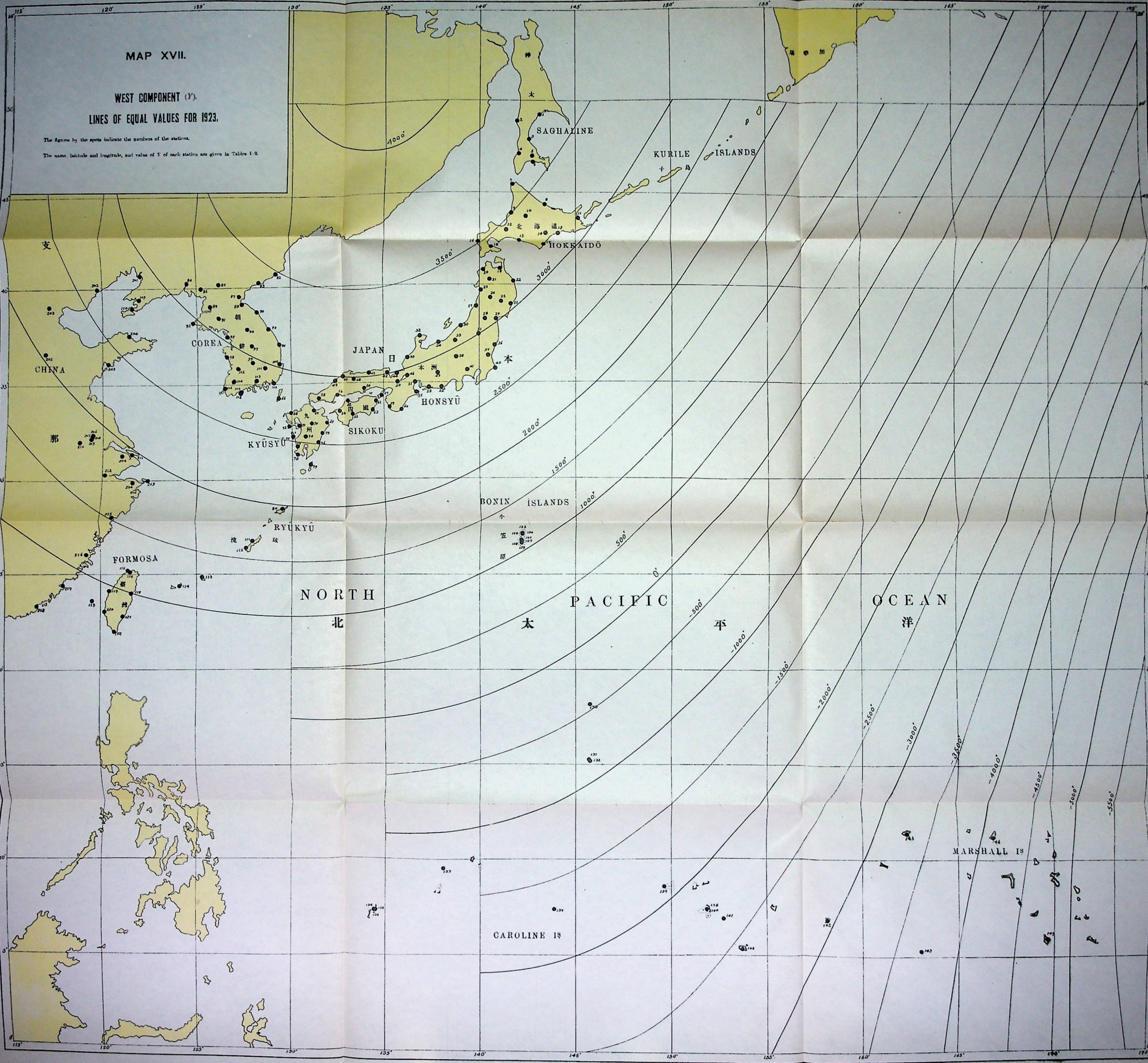
The black spots indicate the stations which were adopted in computation of the empirical equations.

The figures by the spots indicate the numbers of the stations.

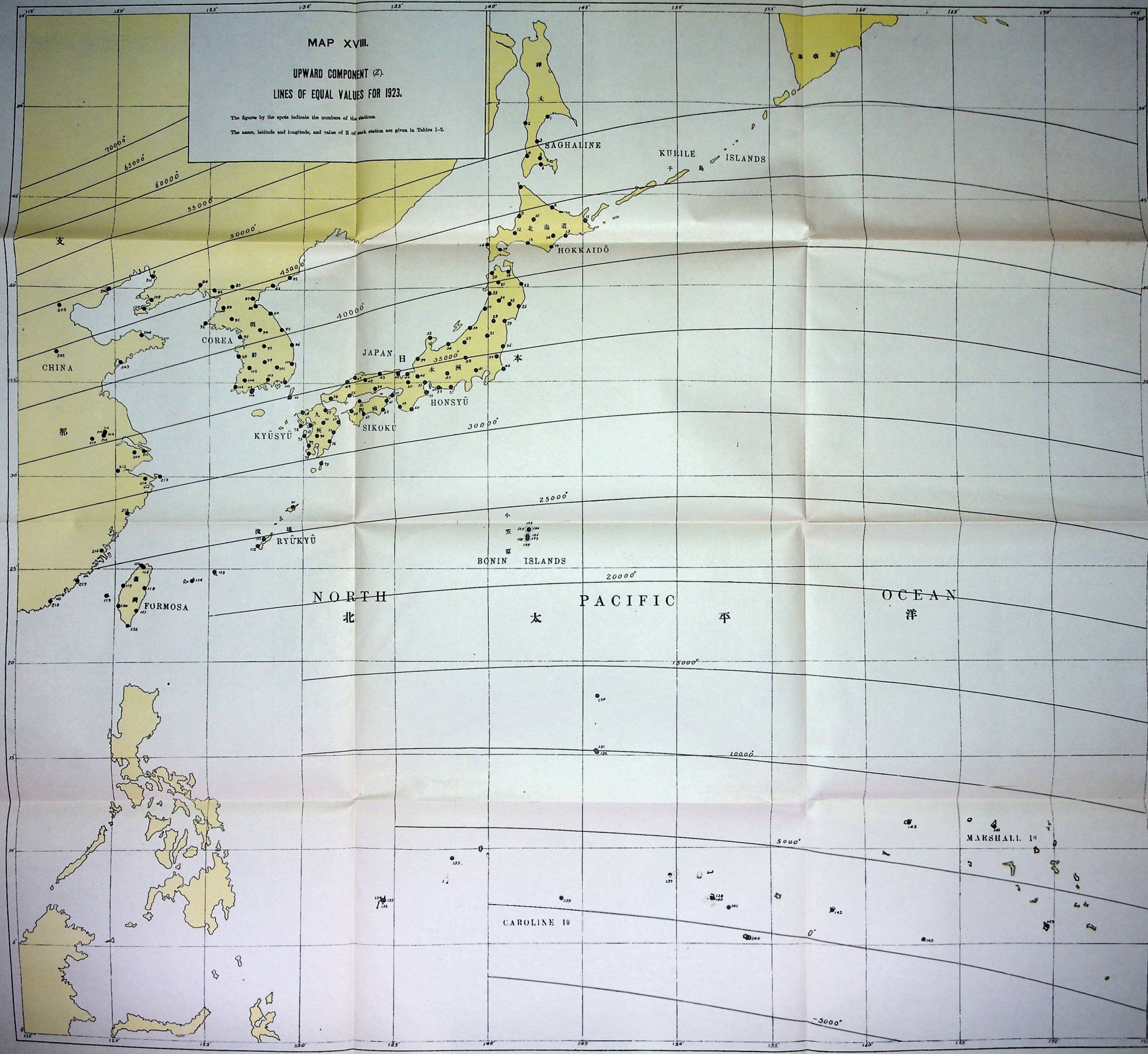
The name, latitude, and longitude of each station are given in Tables 1-2.

The values of Horizontal Intensity at each station are given in Table 12.


MAP XVI.
NORTH COMPONENT (X)
LINES OF EQUAL VALUES FOR 1923.
The figures by the spots indicate the numbers of the stations.
The name, latitude and longitude, and value of X of each station are given in Tables 1-2.
SAGHALINE
KURILE
ISLANDS
HOKKAIDÔ
CHINA
COREA
JAPAN
HONSYÛ
SIKOKU
KYÛSYÛ
RYÛKYÛ
FORMOSA
BONIN ISLANDS
NORTH
PACIFIC
OCEAN
北
太
平
洋
MARSHALL Is
CAROLINE Is
24000
24500
25000
25500
26000
26500
27000
27500
28000
28500
29000
29500
30000
30500
31000
31500
32000
32500
33000
33500
34000
34500
35000
35500
36000
36500



MAP XVII.
WEST COMPONENT (Y).
LINES OF EQUAL VALUES FOR 1923.
The figures by the spots indicate the numbers of the stations.
The name, latitude and longitude, and value of Y of each station are given in Tables 1-2.
SAGHALINE
KURILE ISLANDS
HOKKAIDÔ
COREA
JAPAN
HONSYÛ
SIKOKU
KYÛSYÛ
CHINA
RYÛKYÛ
FORMOSA
BONIN ISLANDS
NORTH PACIFIC OCEAN
北 太 平 洋
MARSHALL Is
CAROLINE Is
4000'
3500'
3000'
2500'
2000'
1500'
1000'
500'
0'
-500'
-1000'
-1500'
-2000'
-2500'
-3000'
-3500'
-4000'
-4500'
-5000'
-5500'



MAP XVIII.
UPWARD COMPONENT (Z).
LINES OF EQUAL VALUES FOR 1923.
The figures by the spots indicate the numbers of the stations.
The name, latitude and longitude, and value of Z of each station are given in Tables 1-2.
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
SAGHALINE
KURILE ISLANDS
千島
HOKKAIDŌ
北海道
COREA
朝鮮
CHINA
支那
JAPAN
日本
本洲
HONSYŪ
SIKOKU
KYŪSYŪ
九州
RYŪKYŪ
琉球
BONIN ISLANDS
FORMOSA
臺灣
NORTH PACIFIC OCEAN
北太平洋
MARSHALL Is
CAROLINE Is